Iron and Steel ENGINEER

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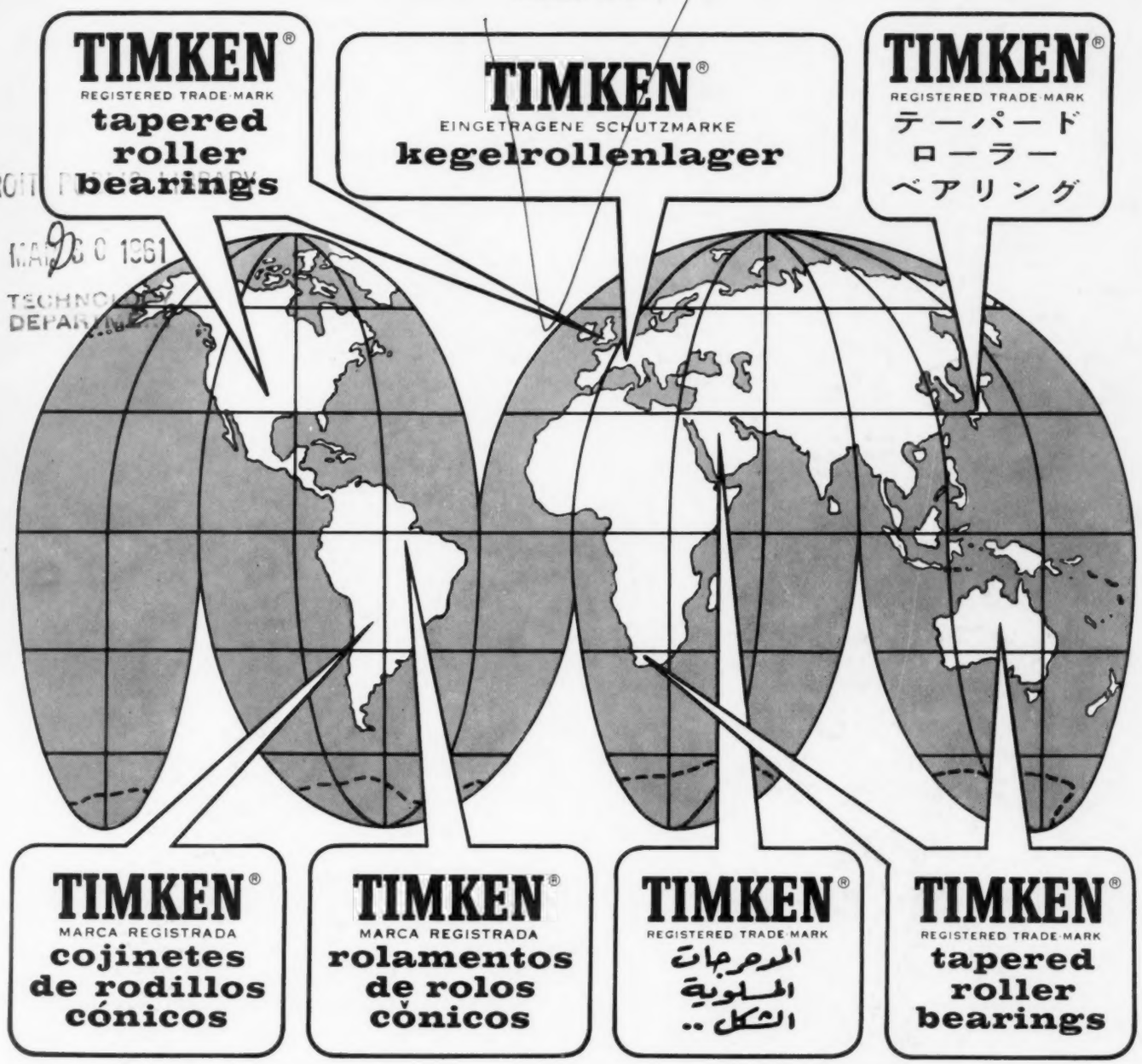

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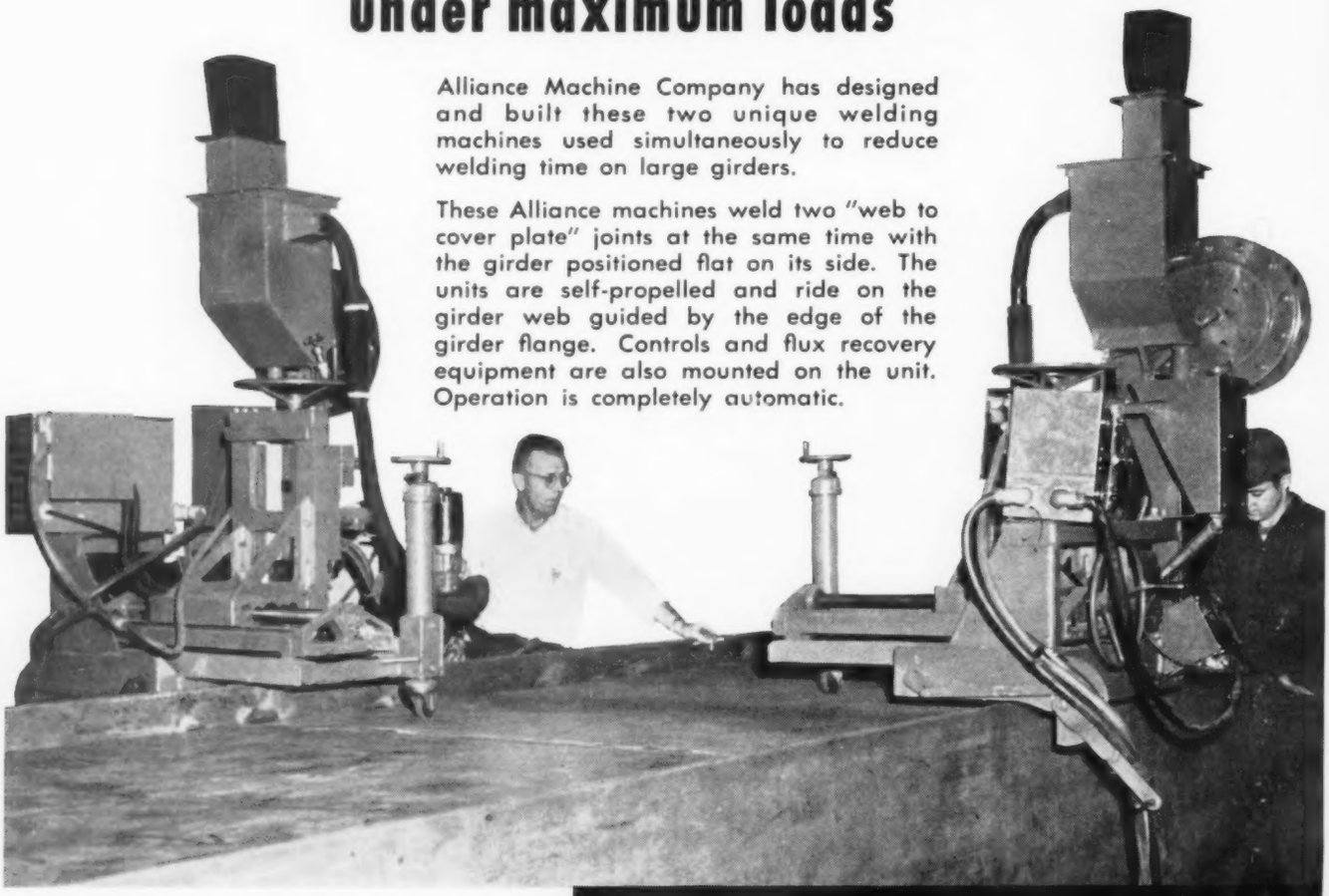

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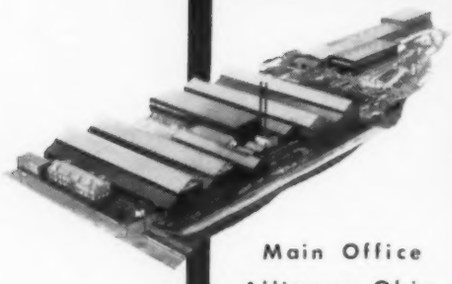

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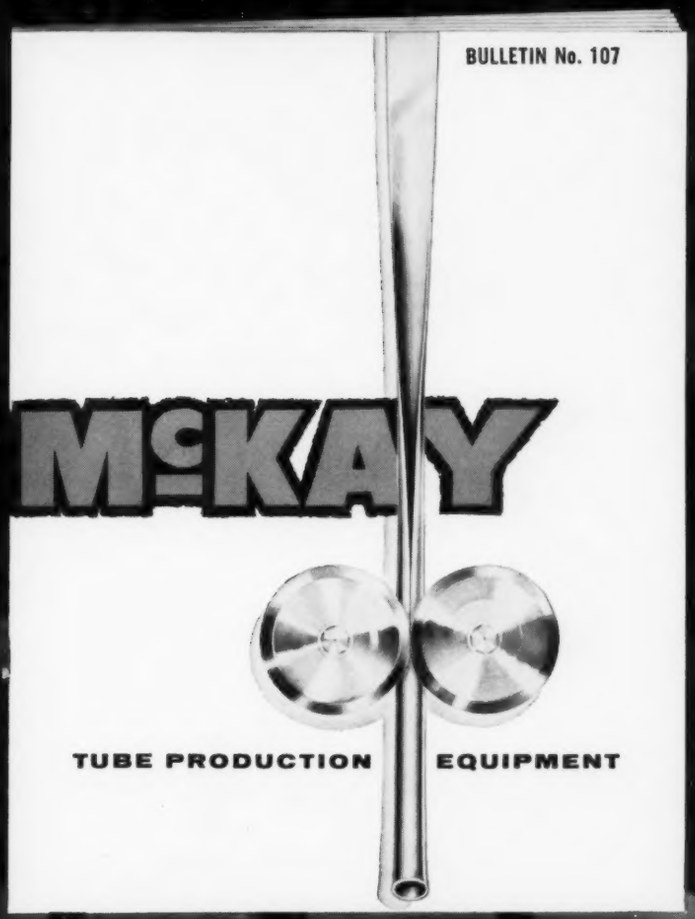

For tube and pipe makers who are feeling the profit squeeze here are forty pages of the latest in high volume, low operating cost production equipment. From steel handling to finished product packaging, this equipment is engineered to minimize tube and pipe production costs — by America's foremost designer and builder of packaged metal forming and fabricating lines. To reserve your copy, write direct or clip and mail the handy coupon below.

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J&L gets new production versatility with two rugged Wean Shearing Lines

Jones & Laughlin Steel Corporation's Cleveland Works Division has added these modern Wean shearing lines to satisfy an increasingly wide range of customer requirements. Both lines can handle 30,000# coils up to 75" wide. The Upcut Shear Line (left) can side-trim and shear strip up to ⅜" thick, with cut-lengths varying from 48" to 500", at a maximum speed of 140 fpm.

The combination Flying Shear Line (right) shears strip up to ¼" in thickness, with maximum cut lengths of 288", at speeds up to 350 fpm. This high-speed Wean line also permits combinations of side-trimming, slitting, temper passing and shearing or recoiling operations.

If you are planning expansion or modernization of your hot rolled strip shearing facilities, a Wean representative will welcome the opportunity to discuss your requirements. Wean's *creative engineering* can mean new profits for you.

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FORGED STEEL ROLLS

Inspecting a one-piece forged steel back-up roll 51 inches diameter, 130 inches long on the barrel— weight 50 tons.

Extensive research and wide experience enable Firth Brown to supply forged steel work rolls of the highest quality for cold rolling ferrous and non-ferrous sheet and strip. Rolls ranging up to 36 inches diameter and 23 tons are in regular production.

Forged steel back-up rolls are also a Firth Brown speciality; they can be supplied either as one-piece forgings or as sleeved rolls up to a diameter of 60 inches and weights of 56 tons.

Firth Brown rolls are widely used also for the hot rolling of non-ferrous metals, particularly aluminium and copper, in both sheet and rod form.

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How Empire-Reeves gets better quality silicon steels, faster

Lee Wilson open coil annealing improves uniformity, facilitates delivery, reduces inventory at Empire-Reeves

"Improved customer service," reports Donald W. Frease, President of Empire-Reeves Steel Corporation," is just one of the assets the addition of the Lee Wilson Open Coil Annealing has given Empire."

"We can now process orders with much greater speed," he continues, "yet we can reduce our inventory in the annealing department, because—by opening the coil—hot gases can saturate the entire coil in a fraction of the time previously required. Cool-down is just as efficient.

"The quality of our silicon steels, as well as others processed through the Open Coil system, is vastly improved because the heat quickly reaches every square inch of the surface of the steel coil. This means it receives a perfectly uniform anneal with an absolute minimum of hardness variation. Because we are handling individual coils instead of continuous strip we have wonderful flexibility. We can process short orders as easily as long runs.

"The Lee Wilson Open Coil Process thus enables us to improve our customer service and our product, and at the same time, gives us the most efficient annealing system available today," Mr. Frease, concludes.

If a better product or more efficient annealing department appeals to you, why not get the last word on annealing practice. The Lee Wilson sales engineer in your area will be happy to meet with you at your convenience.

Donald W. Frease, President of Empire-Reeves Steel Corporation (center), tells J. L. Whitten, Vice President of Sales of Lee Wilson (right), and E. G. Fenton of Empire, the results of Open Coil Annealing at Empire after the first few months of operation.

Overall view of the Lee Wilson Open Coil Annealing installation at Empire-Reeves' Mansfield, Ohio, plant.

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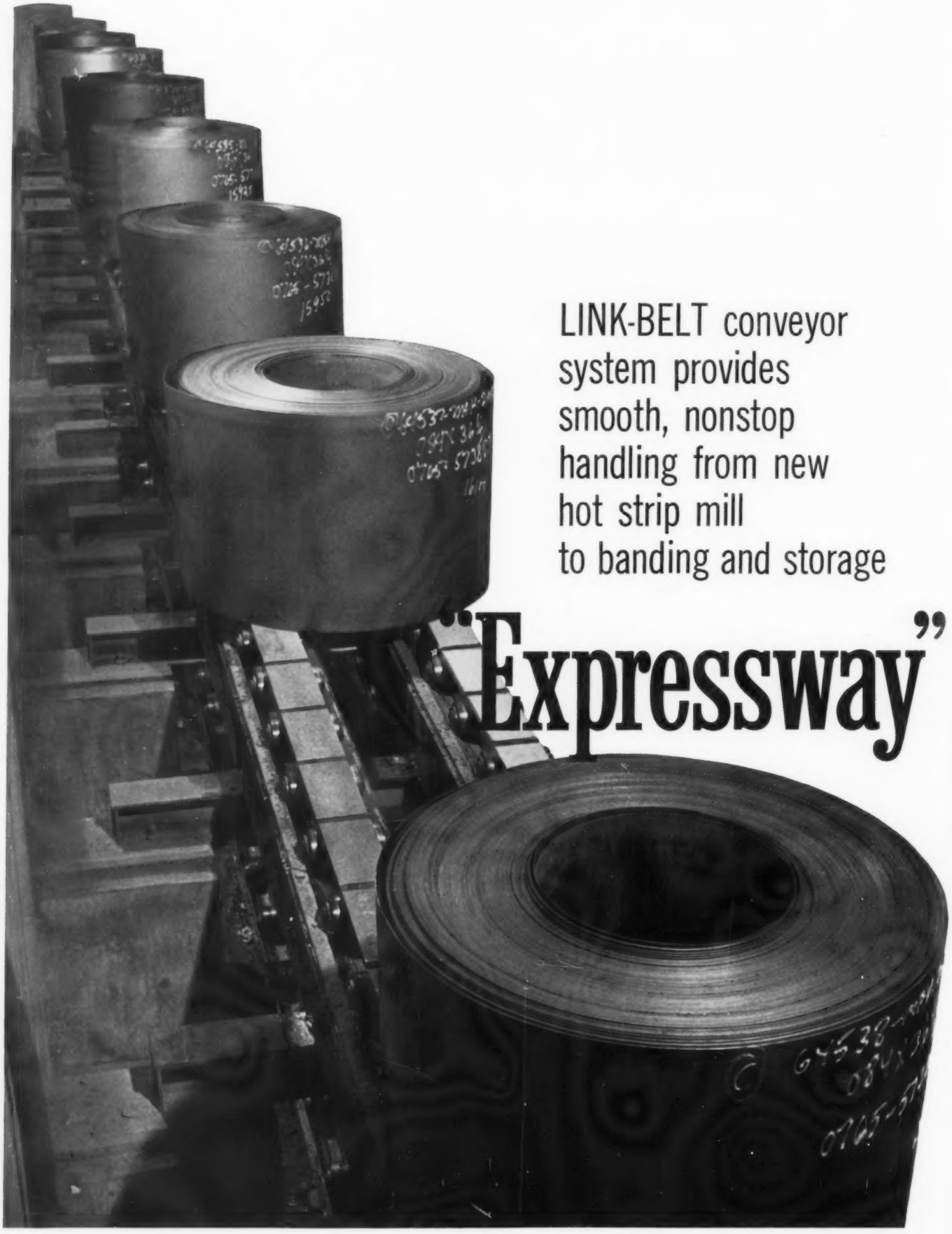


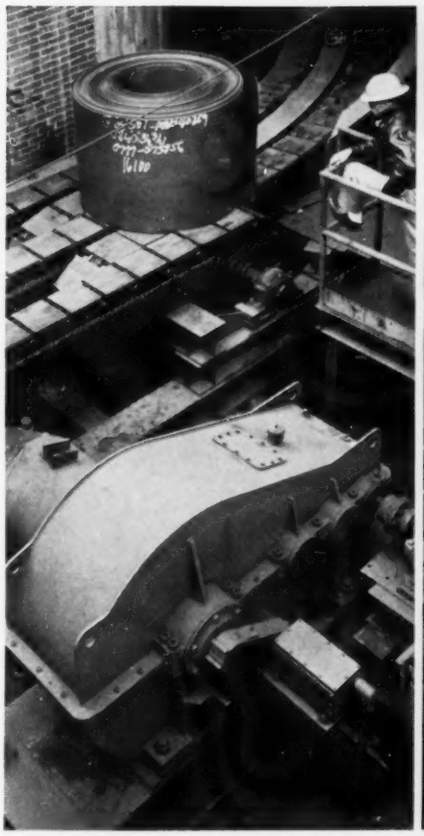
LINK-BELT conveyor system provides smooth, nonstop handling from new hot strip mill to banding and storage

"Expressway"

The new 44-in. semi-continuous hot strip rolling mill at Jones & Laughlin's Aliquippa Works can turn out a coil every 40 seconds. And as fast as the coils are produced, a system of Link-Belt conveyors transports them to a banding and pickup station about 425 feet away. The smooth, continuous Link-Belt route assures gentle handling of the giant coils . . . minimizing telescoping and scuffing of edges.

The Link-Belt system consists of two double-strand flat-top roller chain conveyors, two triple-strand transfer conveyors, one 90-degree continuous turn conveyor, one downtilter and a V-top wide-pallet storage conveyor. An unusual feature of the system is the continuous turn conveyor—an improved method for making a 90-degree directional change in coil travel.

As at Aliquippa, Link-Belt will work with your engineers, consultants and builders of mill and processing equipment to update your handling of coils, any other form of steel, or bulk materials. For complete details, contact your nearest Link-Belt office. Ask for Book 2764. Ask, too, about our 16-mm sound-color film, HANDLING MATERIALS IN THE STEEL INDUSTRY.



SMOOTH TURN—At this 90-degree turn in Aliquippa's Link-Belt system, a transfer conveyor moves coils onto a two-strand continuous turn conveyor. Chains of the turn conveyor have a special pin and joint design that permits bending in a horizontal as well as a vertical plane.

END OF THE LINE—Upon arriving at banding station, coils are lifted from conveyor by hydraulic dolly and operator applies band. Coils are then positioned on downtilter which places them on V-top wide-pallet storage conveyor. Lift pads on downtilter avoid scuffing of coil edges.

for hot coils at Aliquippa

ALSO . . . COILS AT J & L PITTSBURGH AND CLEVELAND WORKS RIDE LINK-BELT CONVEYOR SYSTEMS

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CLEVELAND—Link-Belt car-type conveyor at Cleveland Works is about 1,000 ft. long . . . carries hot coils smoothly around corners up and down inclines.

PITTSBURGH—This double-strand Link-Belt conveyor, one of two installed at Jones & Laughlin's Pittsburgh Works, easily handles coils weighing up to 60,000 lbs.

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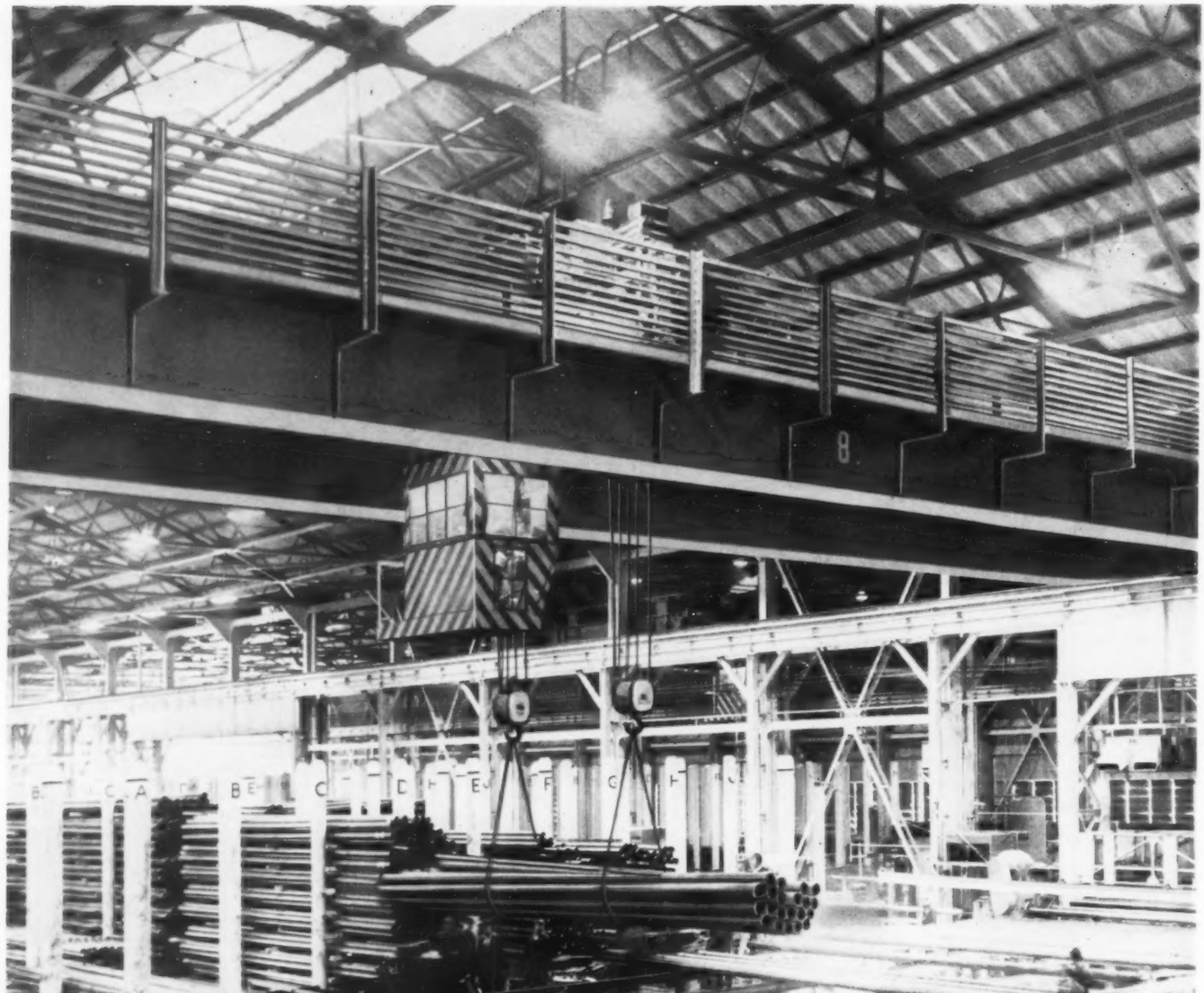

CLEVELAND CRANES

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Crops and Shorts

△ On page 63 is the first installment of a new monthly editorial feature. It will discuss various problems in the business end of steel that should be known and understood by engineers and operators. We believe it will be of interest to readers of the *Iron and Steel Engineer.*

△ Prospects for the steel industry in 1961 are for a gradual, unspectacular improvement in demand throughout the year, according to Russell L. Peters, financial vice president of Inland Steel Co. He looks for a production of about 100,000,000 tons of ingots.

Mr. Peters sees the industry's competitive situation as requiring quick, resolute action by government labor and management. Government must modernize depreciation allowances to encourage replacement of obsolete facilities. Labor must avoid unsound practices which increase costs, and must recognize that excessive wage demands can only weaken job security. Management must develop new products, improve quality, devise new techniques and reduce costs.

△ A Republican senator's observation concerning President Kennedy: "I can't tell whether he's trying to be frank or Franklin."

△ With the aluminum industry celebrating its 75th anniversary, there are six primary producers in the United States, operating 22 reduction plants. The industry makes known their capacity at 2,468,750 net tons per year. Production in 1960 was 2,014,499 tons, for an operating rate of 81.6 per cent.

△ According to Engineers Joint Council, engineers' salaries rose approximately 5 per cent per year between 1958 and 1960.

△ The American Iron and Steel Institute reports that the total payroll for employees of iron and steel companies set a record at $3,889,755,293 in 1960. Payroll costs for hourly workers averaged $3.349 during the year, while fringe benefits cost the companies 47.1 cents per hour. Thus, total employment cost averaged $3.82 per hour.

△ A correspondent observes: "The man who pays his taxes cheerfully, must be, I'm sure, just lying fearfully."

△ To meet the challenge of competitive materials, United States Steel Corp. has been sponsoring "Study in Steel," a campaign to capture the attention of the design world and to create new frontiers for steel.

Bay E. Estes, Jr., commercial vice president of marketing, emphasizes that the company is not in the design business and any designs it develops are available to manufacturers and fabricators with no strings attached. It realizes, however, that its customers owe no permanent loyalty to steel but will use materials that best meet their requirements. The company believes that "if designers are aware of the inherent characteristics of steel, they can produce products that are more practical, more economical to fabricate and more in keeping with the design trend of tomorrow." It is convinced that "steel offers a huge, untapped reservoir of source material for product designers in almost every major commercial and industrial field."

Following a showing in the Pittsburgh area, the design exhibit will tour selected sales areas across the country.

△ A New Jersey man has been sending this letter to a number of congressmen: "Dear Sir—Two things in life are certain: death and taxes. But, thank goodness, death doesn't get worse every time Congress meets."

△ In 1960, total steel production of the European Steel and Coal Community rose to a record 80,000,000 net tons, 15.3 per cent above 1959. By countries, the steel production ran:

	Net tons
West Germany & the Saar	37,440,000
France	19,000,000
Italy	9,040,000
Belgium	7,900,000
Luxembourg	4,490,000
Netherlands	2,130,000

The community's iron production climbed to 59,400,000 net tons.

The United Kingdom also had a record year with 27,200,000 net tons, 20 per cent above 1959 and 12 per cent above the previous record of 1957.

Japan's production was 24,350,000 net tons of ingots, 33.2 per cent above 1959, and 13,100,000 tons of iron, up 25.9 per cent over 1959.

△ It's tough, but modern youths are being forced to shift for themselves—when their dads buy them foreign sports cars.

△ The iron and steel industry in the United States now consists of over 275 companies with plants located in 300 communities in 35 states, according to the American Iron and Steel Institute. About 85 of those companies make the raw steel required to produce their finished products. Most of the other companies are engaged in further rolling and drawing semifinished steel obtained from steel ingot producers. Others produce pig iron.

△ Target dates for National Steel Corp.'s current expansion projects are August, 1961, for the new hot strip mill at Great Lakes and Spring of 1962 for the oxygen steelmaking furnaces. Midwest, another National subsidiary, should be completed this spring. George M. Humphrey, retiring chairman of the company, said there are no further expansion projects in immediate view but future thinking for Midwest includes an integrated steel plant. Commenting on National's decentralized management policy, with separate administrations for each plant, Mr. Humphrey said he believed it resulted in better supervision and better customer contact and service.

budway

Did you know there is a guaranteed way to clean stack gases?

Cleaning your gases is not a simple task. A careful analysis must be made of flue gas temperature, dust composition, and such things as dust loadings and gas volume. It takes a real crew of experts to make sense out of the data, then design, manufacture, and install equipment with *guaranteed* gas-cleaning efficiency.

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Two outstanding examples of Koppers installations are the open hearth furnaces at Fairless Works of United States Steel Corporation, and the blast furnaces at Great Lakes Steel Division of National Steel Corporation. A completely different system was designed and installed by Koppers for the McLouth Steel Corporation. Here, they used pressure-type disintegrators to clean gases from electric furnaces and new oxygen converters. It proved efficient for both steelmaking processes. And Koppers is now installing seven additional electrostatic precipitators and ten additional waste heat boilers to control the gas discharge from open hearth furnaces at the Pittsburgh Works of Jones & Laughlin Steel Corporation.

Koppers will be glad to analyze your operation, too. Write to Koppers Company, Inc., Engineering and Construction Division, Pittsburgh 19, Pennsylvania.

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1. **TAYCO-40** will **not** run out of joints at temperatures up to 3100°F.

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3. Roof life is prolonged. Thin, tight joints prevent brick from slipping out of place when in service. Spalling is retarded.

4. **TAYCO-40** has excellent water retention and smooth workability. Use it for dipped, poured or trowelled joints. Less cement is used; joints are thinner and tighter.

Try TAYCO-40 Silica Cement for your next furnace re-build. Properties and service data are given in Bulletin 507. Write for your free copy.

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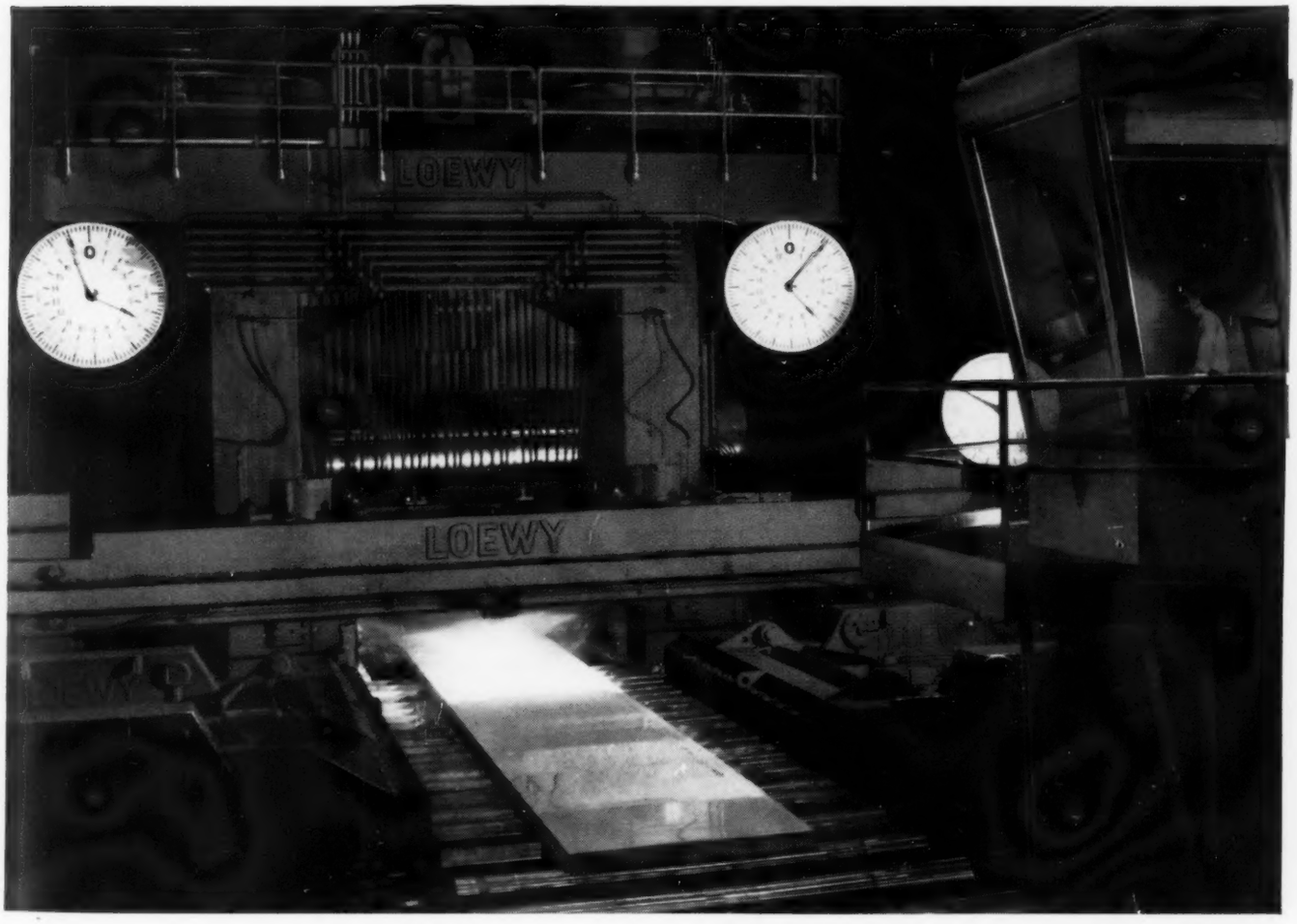
Entry side of 110-in. 4-high reversing hot mill with underdriven edger designed and built by B-L-H for a West Coast metals producer.



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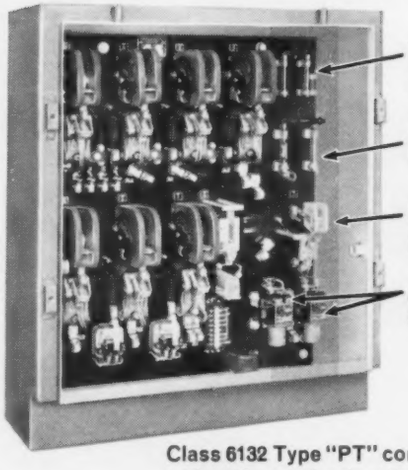


Class 6132 Type "PT" controller with self-contained protection

NOW! LOW-COST MAGNETIC CONTROL FOR DC CRANES

Compact ***EC&M Type "PT" Control*** *—a logical replacement for manual control*

• On any DC crane application up to 55 hp, 230 volts, you now can have all the advantages of *full magnetic* control where manual control formerly was purchased purely on the basis of price. Whether you're modernizing existing cranes or ordering new ones, you'll find type "PT" control far superior to manual control.

Space Saving • compact controllers fit easily in crane cabs, on crane walkways and in congested areas for other mill applications. Front connection permits mounting against walls or girders.

Full Protection • *now* available with self-contained undervoltage and overload protection. Also supplied without protection for use with separate protective panel.

Extra Safety • Exclusive Wright dynamic lowering circuit is the simplest and safest circuit for crane hoist service, gives maximum hook speed without danger of overspeeding. Controller completely enclosed.

Automatic Acceleration • relays adjustable from 0.2 second or more per step. Automatic acceleration reduces wear on motors and control.

Plugging Protection • rectifier-type plugging relay operates from motor counter-emf.

Choice of Master Switches • dynamic lowering controllers furnished with 4-point speed control. Choice of 3 or 4 point master switches on reversing plugging controllers.

Heavy-Duty Construction • mill-type contactors, sturdy design throughout make Type "PT" control suitable for mill accessory drives as well as light industrial cranes. Available in NEMA Type 1 general purpose, Type 1 gasketed, or NEMA Type 3 weatherproof enclosures.

Write for Bulletin 6132 for details on "PT" control with protection

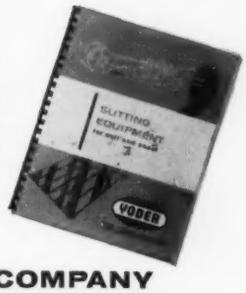
SQUARE D COMPANY

EC&M DIVISION • CLEVELAND 28, OHIO

wherever electricity is distributed and controlled

4155

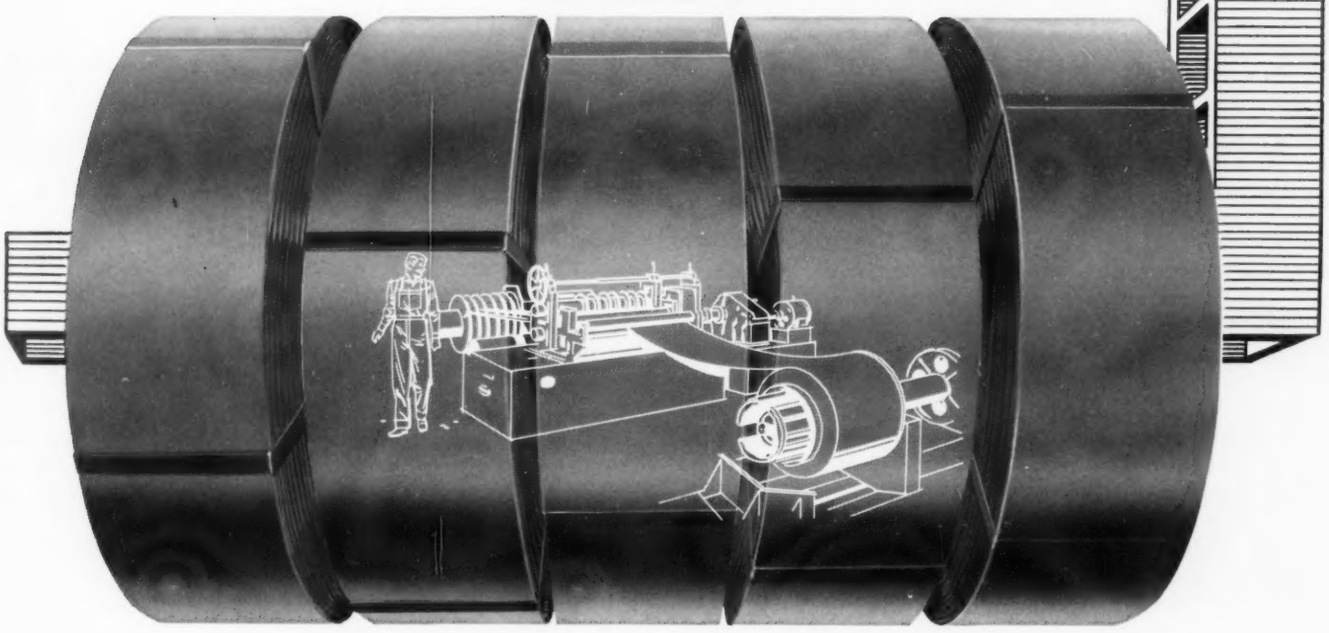
YODER Rotary Slitting Lines Produce the Strip Widths You Need!



Investigate the many advantages of YODER-engineered Slitter Installations. Write today for this comprehensive, 80 page YODER Slitter Manual . . . it's yours for the asking!

THE YODER COMPANY
5495 Walworth Avenue • Cleveland, Ohio

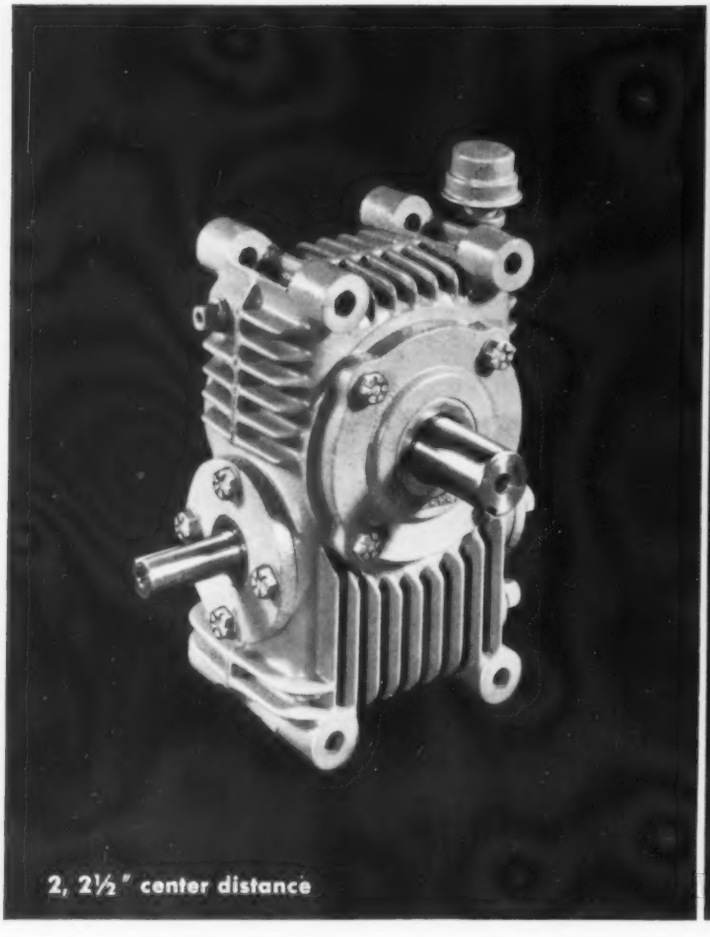
1910 **50 YEARS** 1960



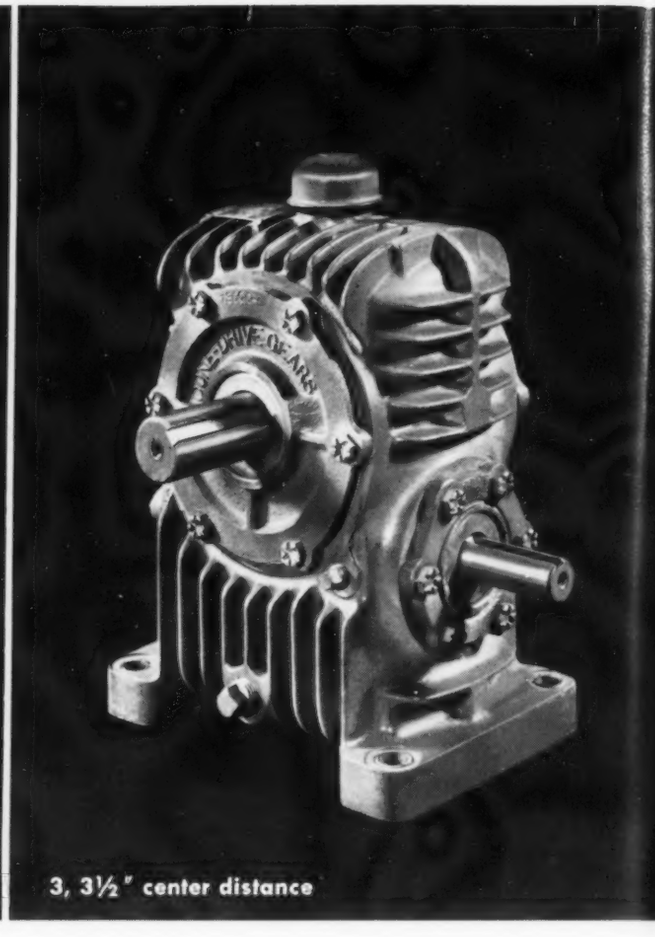
ENGINEERING **YODER** MANUFACTURING

ROTARY SLITTING LINES

PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES



2, 2½" center distance



3, 3½" center distance

4, 5, 6

Custom-build Your Worm Gear Drive from . . .

OVER 200,000 STOCK C

The four "worm-under" speed reducers shown above represent only eleven sizes of standard, Cone-Drive units. Also standard are 15", 18", 22", and 24" center distance units. Cone-Drive worm gear reducers are available in ratios from 5:1 to 4900:1 and up to over 1200 HP capacity. All units feature the double-enveloping principle in which the worm and gear wrap around each other for greatest tooth contact, strength, smoothness, shock-resistance and quietness of operation.

All Cone-Drive worm-gear reducers feature heavy, ribbed, nickel-iron castings for maximum strength and heat dissipation. Heavy-duty taper roller bearings provide anti-friction support to both worm and gear shafts. Chrome-molybdenum-nickel steel worms and tin bronze gears provide long life and high strength. The Cone-Drive design also gives the exclusive benefit that, in service, both gear and worm tend to regenerate their true form . . . worm and gear wear "in" rather than "out."

Standard Options

By selecting various options, standard units can be obtained to fit almost any drive requirements. By taking advantage of these options in the early design stages, you can often simplify design and improve performance, too. Including size and ratio ranges and options available, Cone-Drive Gears offers over 200,000 worm-gear speed reducer combinations that are standard, shelf-hardware items. Special sizes and ratios can be furnished on a quotation basis. Write for Bulletin CD-218 for complete details.

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

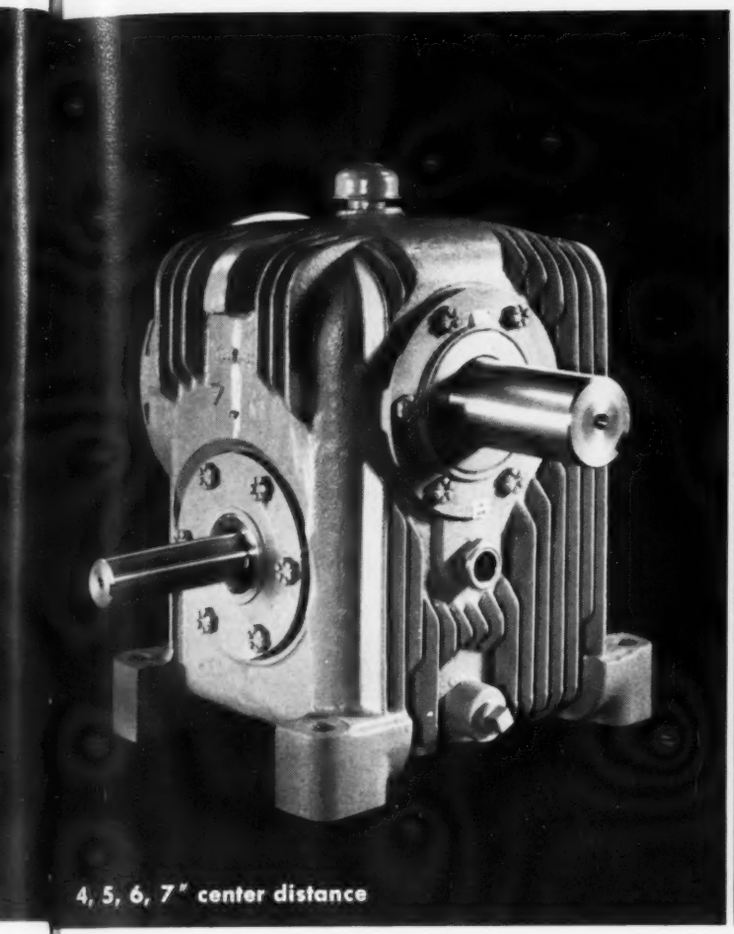
7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS

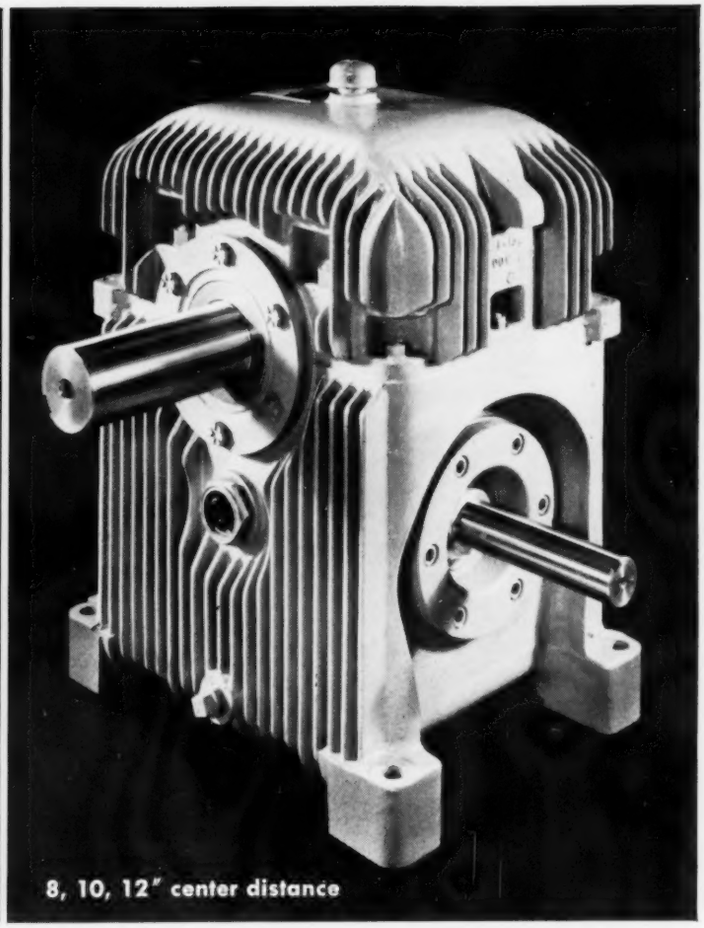
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS



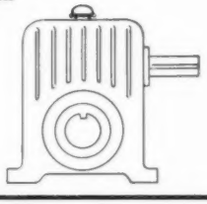
4, 5, 6, 7″ center distance



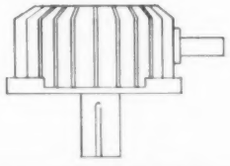
8, 10, 12″ center distance

K CONE-DRIVE REDUCERS

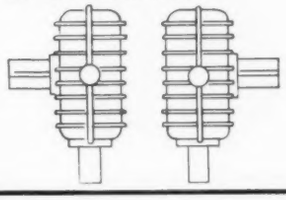
WORM-OVER



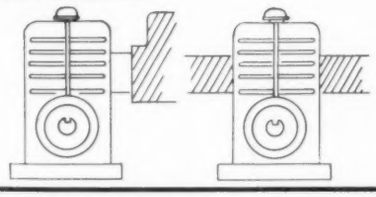
VERTICAL GEARSHAFT



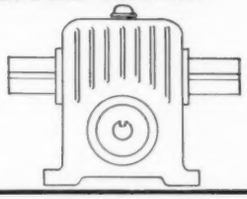
RIGHT- OR LEFT-HAND SHAFT



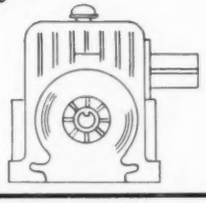
SHAFT MOUNTED



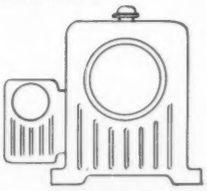
DOUBLE-EXTENDED GEARSHAFT



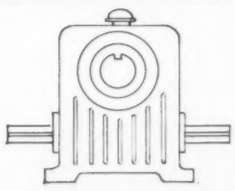
FAN-COOLED



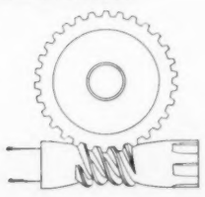
DOUBLE REDUCTION



DOUBLE-EXTENDED WORM SHAFT



GEARSETS & MOUNTINGS



Another MX Test System at work...

Stainless steel seamless tube passes through loading, penetrant, emulsifier and water wash stations of automatic Zyglo Test Unit. Lower view shows complete unit with inspector at right. Installation is 33' x 50' x 11', biggest automatic Zyglo yet built. Shipped to Ellwood City plant of National Tube Division, U. S. Steel Corporation.

Better Stainless Seamless Tube--with Automatic Test

Reliable Crack Detection—by Fluorescent Penetrants

Where end-service is critical, as in nuclear reactors, thorough but efficient testing is required. This, the largest automatic Zyglo-Pentrex Unit yet built,—is engineered and produced by Magnaflux. It tests stainless steel seamless tubing, in lengths to 40 feet, in sizes from ½" to 10¾" OD. Processing of tubes up to 3½" D. takes about 3 minutes each; larger sizes, weighing up to 4,000 lbs., about 6 minutes. Heavy duty vee-fixture conveyors handle loads as high as 20 tons at a time.

All operation is fully automatic, except for actual inspection. Tubes are conveyed through the specially engineered, time-sequenced flooding stations for penetrant, emulsifier, water wash and wet developer, drying, and finally to the hooded inspection area. Here, power rotated under a battery of high wattage black lights, fluorescent indications show all seams or cracks, and are marked by the inspector. Run-out rollers then remove tubes from the unit.

This Zyglo unit is another example of Magnaflux' capability to engineer and manufacture complete testing-handling systems for seamless and welded tubing, billets and tube rounds—in any capacity, for any nonmagnetic or magnetic metal.

The unique experience we have thus developed is at your service,-to improve your output, simplify testing and cut costs. Phone our local MX Field Engineer or write to Magnaflux Corporation, 7332 W. Lawrence Avenue, Chicago 31, Illinois.

MAGNAFLUX CORPORATION
TEST SYSTEMS

A SUBSIDIARY OF GENERAL MILLS

MX Test Systems Include MAGNETIC PARTICLE, FLUORESCENT PENETRANT, THERMOGRAPHIC, EDDY CURRENT, ULTRASONIC, STRESS ANALYSIS, RADIOGRAPHIC TESTING, DYE PENETRANT & MAGNETIC FIELD

IT'S NOT TOO EARLY TO THINK OF NEXT WINTER'S COAL HANDLING PROBLEMS

PENNSYLVANIA FROZEN COAL CRACKERS WILL PREVENT

- **Hopper jams**
- **Overloaded conveyors**
- **Slowdowns**
- **High labor costs**

Get ready *now*—for the worst conditions next winter can bring. Investigate Pennsylvania Frozen Coal Crackers.

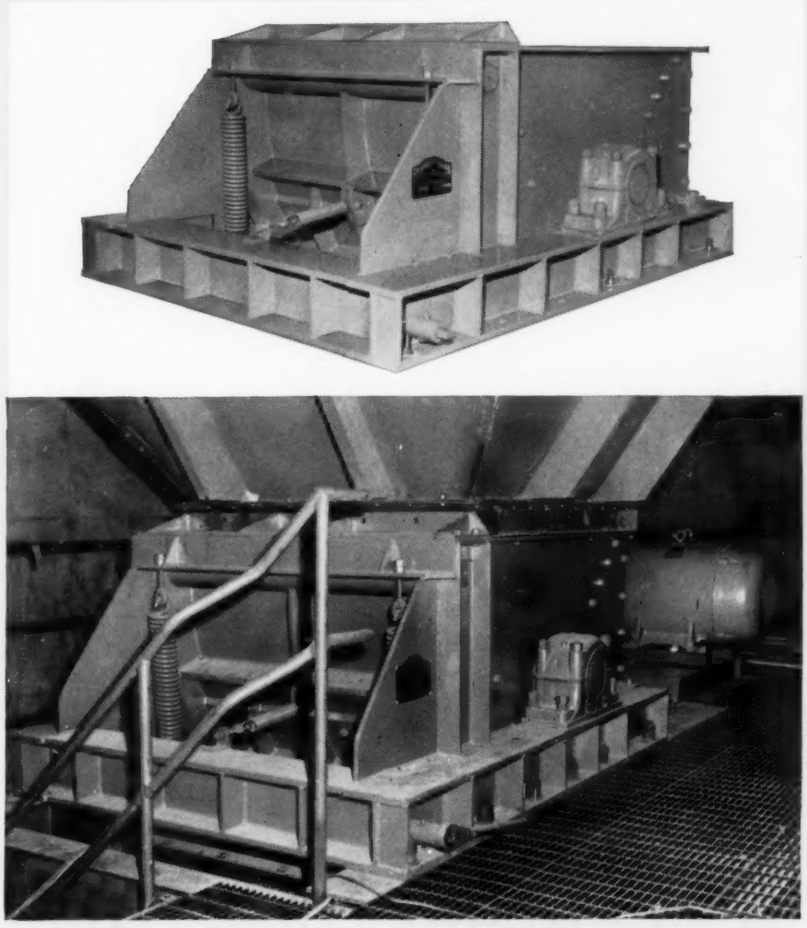
These are the crushers especially designed and widely used for handling frozen coal at track delivery points and storage yards.

OPERATION

Wide feed openings permit use of *open-throated hoppers.* Frozen masses of coal are dumped (with rotary car dumpers) directly into hoppers. No need for grates. Frozen coal works its way freely to the hopper bottom where the crackers' special teeth break it up.

Result—uniform product with limited top-size and minimum fines is fed conveyors, providing protection from overloads . . . insuring continuous flow of coal.

Breaker plates can be opened in warm weather, permitting coal to pass without operating crusher.



30 x 60 Single Roll Pennsylvania Frozen Coal Cracker in service at Merrimack Steam Station, Public Service Company of New Hampshire, Concord, N.H.

OTHER FEATURES

Built-in tramp iron protection. Low head room requirements. Easily adapted to existing hoppers. Capacities up to 1200 TPH. Available in single or twin units.

Write today for new Pennsylvania Bulletin 2013 . . . or call your nearest Pennsylvania representative.

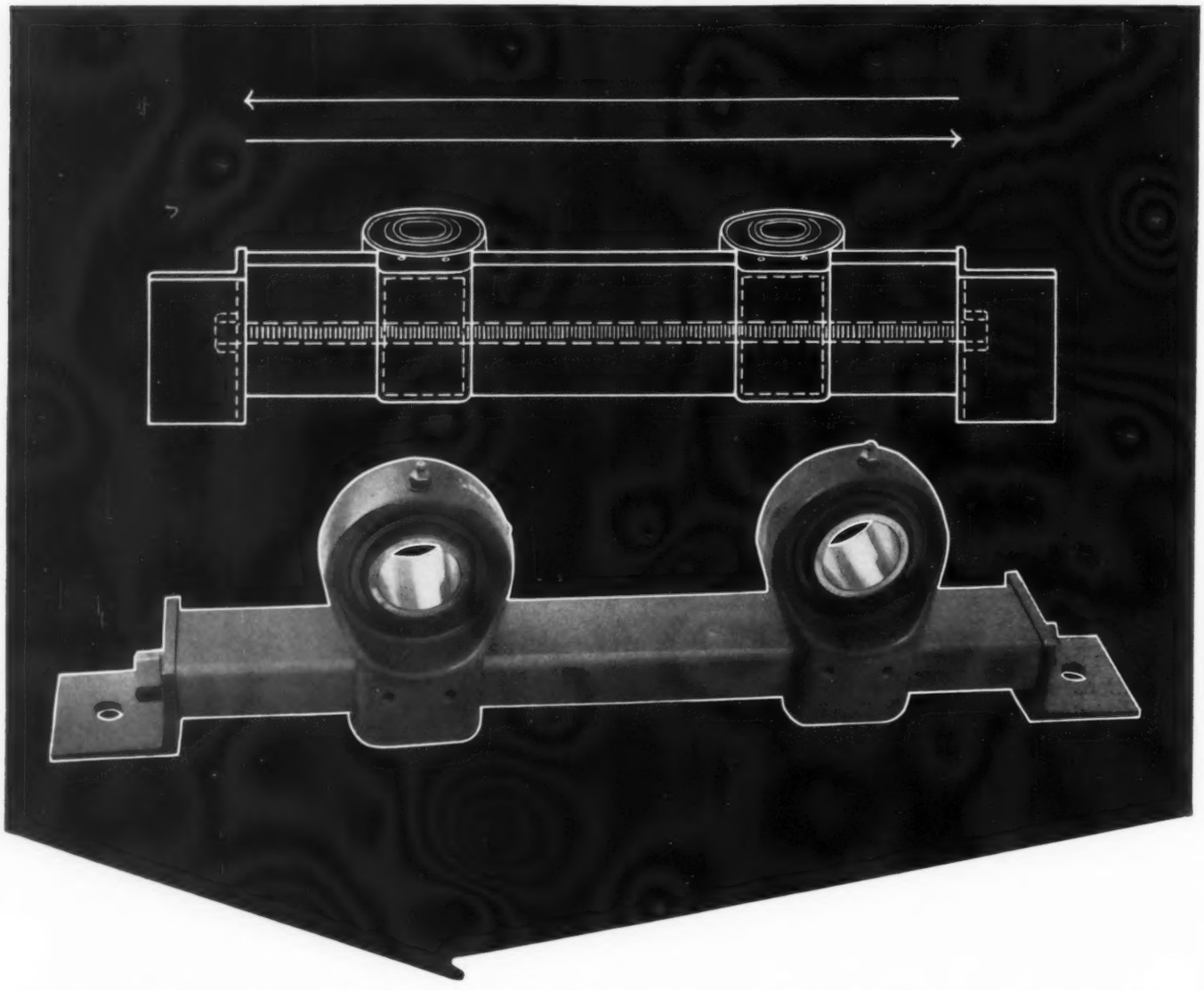
PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

★ ★ ★

Over 50 years concentrated experience in mechanical reduction. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA CRUSHERS

BATH-BUILT



A Bearings, Inc. design saved our customer time, trouble and dollars!

Shown is a take-up unit designed by our engineers to perform two jobs simultaneously! The unit's first job is to take up slack in a large belt—Its second job is to keep indexing apparatus in the right spot on the belt.

Previously, the indexing was adjusted separately to a new position every time the belt had to be tightened, no matter how much or how little the adjustment. It was a costly, time-consuming job that kept the equipment out of production for hours.

Now, with this unit, belt take-ups and indexing adjustments are both performed with one turn of the screw on which the two pillow blocks ride.

We solved *this* customer's bearing problem. The answer to *your* problem is as near as your telephone! Call the branch nearest you now!

Providing bearing service

in the North ➤ **BEARINGS, INC.**

DELAWARE: Wilmington • **ILLINOIS:** Neiman Bearings Co., E. St. Louis • **INDIANA:** Ft. Wayne • Indianapolis • Muncie Terre Haute • **MARYLAND:** Baltimore • **MISSOURI:** Neiman Bearings Co., St. Louis • **NEW JERSEY:** Camden • Newark

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NEW YORK: Balanrol Corp., Buffalo • Niagara Falls • **OHIO:** Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton Lima • Lockland • Mansfield • Painesville • Toledo • Youngstown • Zanesville • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York **WEST VIRGINIA:** Charleston • Huntington • Parkersburg • Wheeling

in the South ➤ **DIXIE BEARINGS, INC.**

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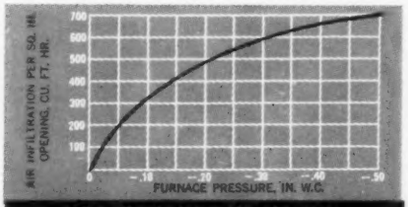
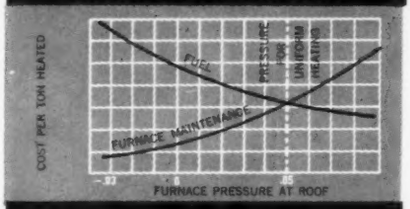
Why **furnace pressure control** should be considered the primary combustion control on heating and melting furnaces



The effect of negative furnace pressure on air infiltration.



The effect of furnace pressure on fuel cost and furnace maintenance.

When a negative pressure exists inside a furnace, appreciable quantities of air pass through the walls and openings of the furnace structure. Actual tests have shown that even in an apparently tight furnace the amount of air infiltration can be as high as 40% of the total air required for combustion.

Thus, uncontrolled air infiltration can completely negate the function of accurate fuel-air ratio control. It leads to fuel waste, uneven and irregular heating, excessive cooling of the furnace, and flame impingement on the contents and walls.

On the other hand, uncontrolled high furnace pressure causes undue heat loss through the furnace walls and openings, the possibility of dangerous blow-outs when doors are opened, and high refractory maintenance cost.

In a properly designed furnace, the furnace pressure that is best for effective heating or melting is also the pressure that provides an optimum relationship between fuel costs and maintenance costs. Precise control of furnace pressure at this one best value is a first necessity for efficient operation.

...and why **GPE Controls** can bring more experience than any other control builder to furnace pressure control applications

GPE Controls Hydraulic Pressure Controller. Thousands of these units are now providing precise pressure control on heating and melting furnaces of all kinds.
GPE Controls Electronic Furnace Pressure Transmitter. Electrohydraulic control system combines advantages of electric transmission and hydraulic operation.

Two generations of heating and melting furnace operators and builders have relied on GPE Controls for furnace pressure control. GPE Controls developed the concepts that made furnace pressure control practical.

The pressure range of a GPE Controls furnace pressure controller is -0.05 to $+0.15$" w.c. Accuracy of $\pm 1\%$ is equivalent to holding the "zero pressure" level of the furnace within 3" vertically—the degree of accuracy that GPE Controls equipment is designed to provide.

GPE Controls now adds the advantages of electronic transmission to the proved hydraulic control system. The furnace pressure transmitter shown at the left converts the furnace pressure signal to a high-level d.c. voltage signal. Used with GPE Controls electronic controller and electrohydraulic valve actuator, it eliminates long pneumatic signal lines and hydraulic lines. The same furnace pressure signal can operate not only the control but also recorders and indicators. Installation and maintenance are both greatly simplified.

Always be sure to specify GPE Controls furnace pressure control—the primary combustion control.

Write for descriptive literature

GPE Controls, Inc.

240 East Ontario Street • Chicago 11, Illinois

GPE Controls

A Subsidiary of GENERAL PRECISION, Inc.

ARMCO

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WEIRTON STEEL COMPANY

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USS

Shaw-Box Ladle Crane. A 4-girder, 9-motor crane with 54 foot span. 90-ton ladle holds 200 tons of molten steel. 75-ton auxiliary trolley handles lighter loads.

Shaw-Box Bucket Magnet Gantry Crane. Our gantries are used to handle plate, slabs, ingots, and scrap. They are built to obtain freedom from whipping and to resist impacts.

These 10 top steel companies solve handling problems with Shaw-Box® Cranes

Standard crane designs of 30 years ago can't solve materials handling problems for today's steel mills. Problems unique to each mill demand cranes especially engineered for the job.

That is why these ten leading steel companies developed their own crane specifications — or chose modern AISE standards. Each awarded the job of constructing the crane to Shaw-Box.

Shaw-Box produces cranes of any type and capacity to AISE standards or your own. Your particular materials handling problems come first. We are not bound by traditional concepts of design. The crane you want is developed for top efficiency, easy maintenance, power economy, and complete safety.

Call in one of our engineers. He will gladly discuss specifications and tell you about our standard AISE designs for 5 to 500-ton cranes. We welcome the opportunity to serve you.

MAXWELL MANNING & MOORE INC. TRADE MARK MM&M

60 K-2

SHAW-BOX® CRANES

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MANNING, MAXWELL & MOORE, INC.

ELECTRIC OVERHEAD CRANE INSTITUTE E.O.C.I. MEMBER

Shaw-Box Crane & Hoist Division • Muskegon, Michigan
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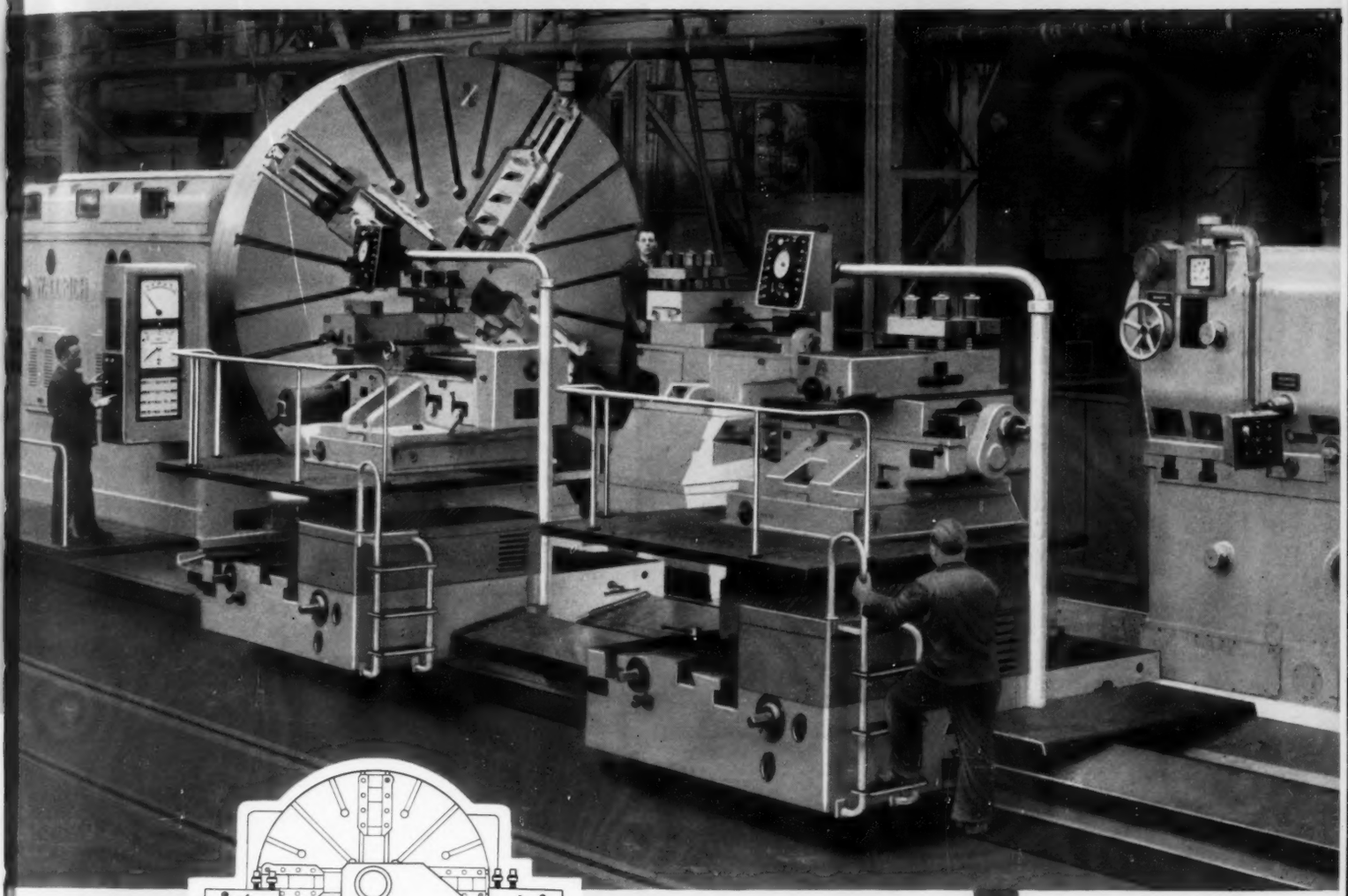
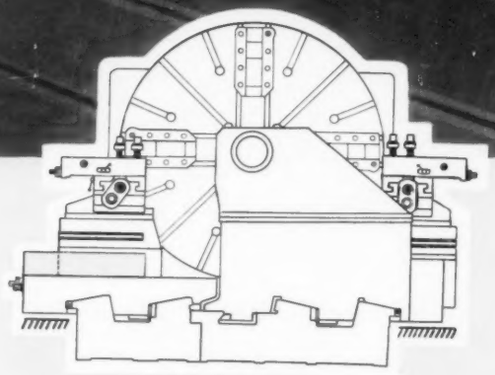
For the manufacturer of large equipment...





WALDRICH-SIEGEN LATHES

to 16′ swing and 66′ B.C.
All prismatic ways for long life and accuracy.
Extremely heavy design for maximum chip removal.
All functions controlled from the pendant at any saddle.

NEW

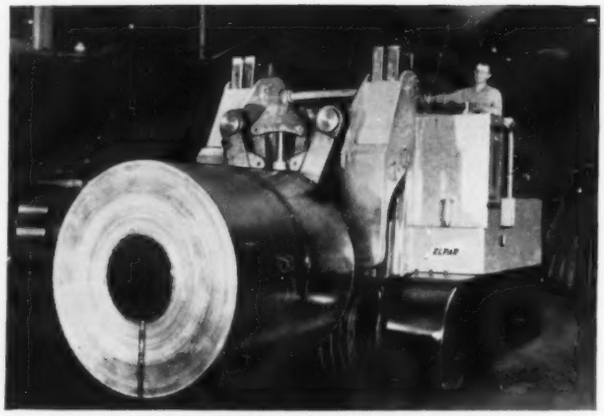
Feed case design permits the mounting of the bed in pit with ways on floor level for easy accessibility of the machine.

AMERICAN WALDRICH MFG. CORP.
1232 Penn Avenue, Pittsburgh 22, Pa.
HEAVY MACHINE TOOLS

WALDRICH SIEGEN

H. A. WALDRICH G.M.B.H
SIEGEN - GERMANY

This 35,000-pound giant is shown handling huge aluminum billets—four at a time.



Another heavy duty ELPAR ram truck designed for handling steel coils. Built for handling efficiency and safety.

An *ELPAR* fork truck for every handling job

1 to 20 tons capacity—with more than 40 standard models

Cut your truck operating costs with ELPAR fork trucks. Built to match the finest equipment in your shop, they need a minimum of maintenance and repair—even on the toughest jobs. And, they run on low-cost electric power.

There is a model for every handling task, and an experienced ELPAR representative to help you pick the best one for your plant.

WRITE FOR THIS CATALOG
Complete details on all heavy duty ELPAR fork and ram trucks.

ELPAR
ELECTRIC TRUCKS

The Elwell-Parker Electric Company
4549 St. Clair Avenue
Cleveland 3, Ohio

In Canada: International Equipment Ltd.

This ELPAR Titan is designed to load coils weighing up to 20,000 pounds in box cars.

Handling coils of steel weighing up to 20,000 pounds is a typical job for the ELPAR Titan Series.

Add flexibility to your ELPAR trucks with special attachments like this clamp used to speed handling of wire fencing.

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D.C., at 25 cents . . . . patents reviewed cover period October 18, 1960 to November 15, 1960

MANUFACTURE OF STEEL WITH HEAT RECOVERY

△ U. S. 2,958,597, issued Nov. 1, 1960 to Thomas C. Churcher and assigned to The British Oxygen Co. Ltd., describes a process for the manufacture of steel in which molten iron from a blast furnace or a cupola is treated to effect a partial refining, and the treated metal is subsequently converted to steel in a steelmaking furnace, such as an open hearth furnace, an electric furnace or a converter.

It is an object of the invention to provide a steelmaking process of this type in which efficient use is made of the heat generated in the various process steps, thus enabling the process to be operated with increased heat economy.

According to the present invention, the process for the manufacture of steel consists of treating molten iron from a blast furnace and/or a cupola by allowing it to fall in the form of fine streams or droplets through a reaction zone in contact with an oxidizing gas mixed with steam, converting the treated metal to steel in a steelmaking furnace, feeding fume-laden gas leaving the reaction zone to the lower part of the blast furnace or cupola, and using hot waste gases from the steelmaking furnace to raise steam for mixture with the oxidizing gas. The fume-laden gas assists in maintaining the temperature of the blast furnace or cupola, and moreover, the iron oxide present therein as fume is recovered.

AGGLOMERATION OF IRON ORE FINES

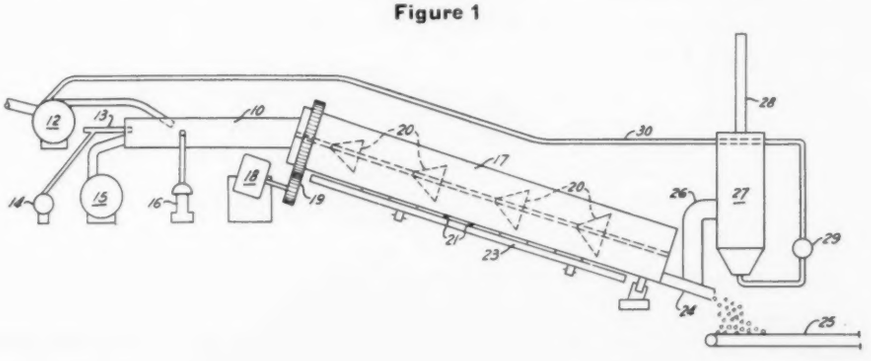
△ U. S. 2,958,596, issued Nov. 1, 1960 to William T. Purvance and assigned to United States Steel Corp., describes a method and apparatus for agglomerating iron ore fines.

As shown in Figure 1, the apparatus includes an elongated stationary chamber 10, a blower 12 for introducing fines to the chamber, a burner 13 for introducing fuel to the chamber from a source 14, a fan 15 for introducing combustion air to the chamber and a pump 16 for introducing an atomized water spray. The ore is approximately all minus 200 mesh, and if coarser, is ground to this fineness before reaching the blower 12. Fuel introduced through the burner 13 is burned with air introduced from the fan 15 to produce a temperature of about 450 to 650 F within the chamber. The resulting mixture of hot gas and fines is treated with a relatively cold atomized water spray supplied by pump 16 to produce a water content of about 15 to 20 per cent by weight in the gas stream laden with fines. It appears critical to the successful practice of the invention that the water does not immediately vaporize.

The heated and moistened gas and fines discharge from the chamber 10 into the upper end of an elongated sloping rotary drum 17, which revolves slowly. The drum can be driven by any suitable means, such as a motor 18 and gearing 19. A series of conical baffles 20 are mounted within the drum to rotate with it, and direct the fines against the relatively cool inside surface of the drum where they deposit as a hard crust. The baffles attain a temperature approximating that of the gas and ore stream, which temperature minimizes deposition of ore on them. The drum wall contains a number of radially movable plungers 21 distributed throughout its area. Normally the plungers are held in retracted position by springs 22, which encircle each plunger outside the drum. An idler roll 23 is journaled alongside the drum to rotate on an axis parallel to the drum axis. The outer ends of plungers 21 engage the roll and the plungers thus are pushed into the drum as they rotate past the roll. This action breaks away chunks of the crust from the inside surface of the drum. These chunks constitute finished agglomerates which discharge from the lower end of the drum.

An outlet chute 24 is positioned

Figure 1



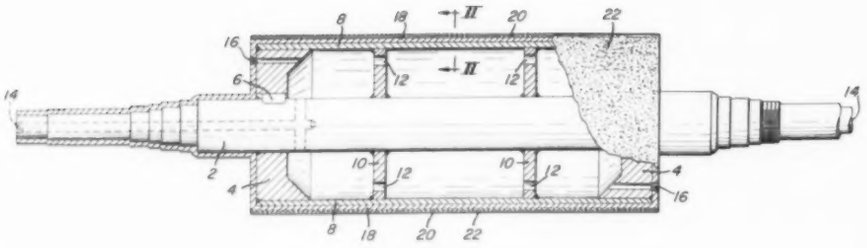


Figure 2

to receive material discharged from the lower end of drum 17. Agglomerates discharge from this chute to a receiver, such as a conveyor 25. Exhaust gases and dust pass from chute 24 into a duct 26, dust catcher 27 and stack 28. A blower 29 returns recovered dust from the dust catcher through a duct 30 to the blower 12 for recycling through the apparatus.

CONDUCTOR ROLL

△ U. S. 2,958,742, issued Nov. 1, 1960 to James C. Palmer and assigned to United States Steel Corp., provides a conductor roll for supporting and applying current to a steel strip being processed. In the manufacture of electrolytic tinplate, it is necessary to apply current to the strip for cleaning, pickling and plating. It is for such purpose that this conductor roll is particularly adapted.

As shown in Figure 2, reference numeral 2 indicates a one-piece shaft. A pair of end bells or supports 4 are keyed to the shaft 2 by means of keys 6 and are also welded to it, as shown. A barrel 8 is welded to the end bells 4. Plate supports or disks 10 are also provided between the end bells 4 with the disks 10 being welded to the shaft 2 and barrel 8. Holes 12 are provided in the plates 10 to permit cooling water circulation. Openings 14 are provided in the ends of shaft 2 for delivering cooling water to and from the interior of the roll. Holes 16 are provided in the end bells 4. The parts so far described are all made of steel. After these parts are fastened together, a casing 18 is supplied over the entire surface of the roll body and shaft, as shown. The casing 18 is made of copper or a copper alloy of high electrical conductivity. The copper is supplied in molten form as by welding and may be therefore considered as a cast material. The casing 18 is then machined all over to size and dimension. The thickness of the casing is preferably between $\frac{3}{8}$ and $\frac{1}{2}$ in. The barrel portion of the casing is then electroplated with copper or a copper alloy 20. The copper plate 20 has a preferable thickness of between 0.003 and 0.005 in. This copper plate fills up the pores in the casing 18. The copper plate 20 is shot blasted with shots having a screen size of 0.100 in. or less. The surface of coating 20 is then electroplated with chrome 22 to a thickness of about 0.004 to 0.005 in. This chrome plate forms the strip supporting surface of the roll and will have a surface corresponding to the shot blasted surface of plating 20. It is desirable that the shot be no rougher than that designated above so as to prevent the strip from carrying solution along with it. The holes 16 remain open until after manufacture of the roll is completed so that gases or vapors generated during manufacture can escape, thus preventing pressure build-up and explosions. The openings 16 are then plugged to make the roll water-tight.

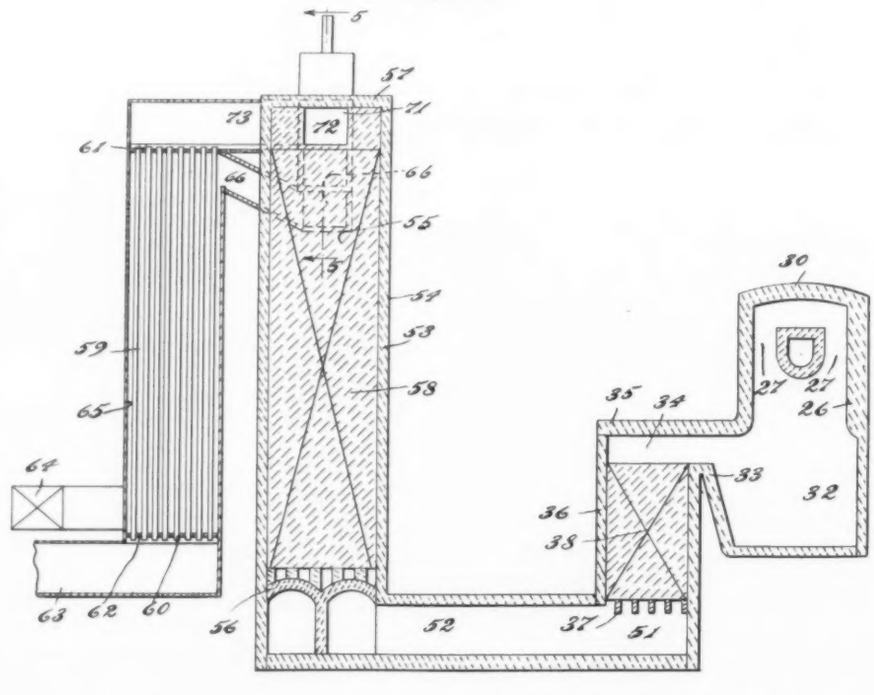
OPEN HEARTH FURNACE REGENERATOR

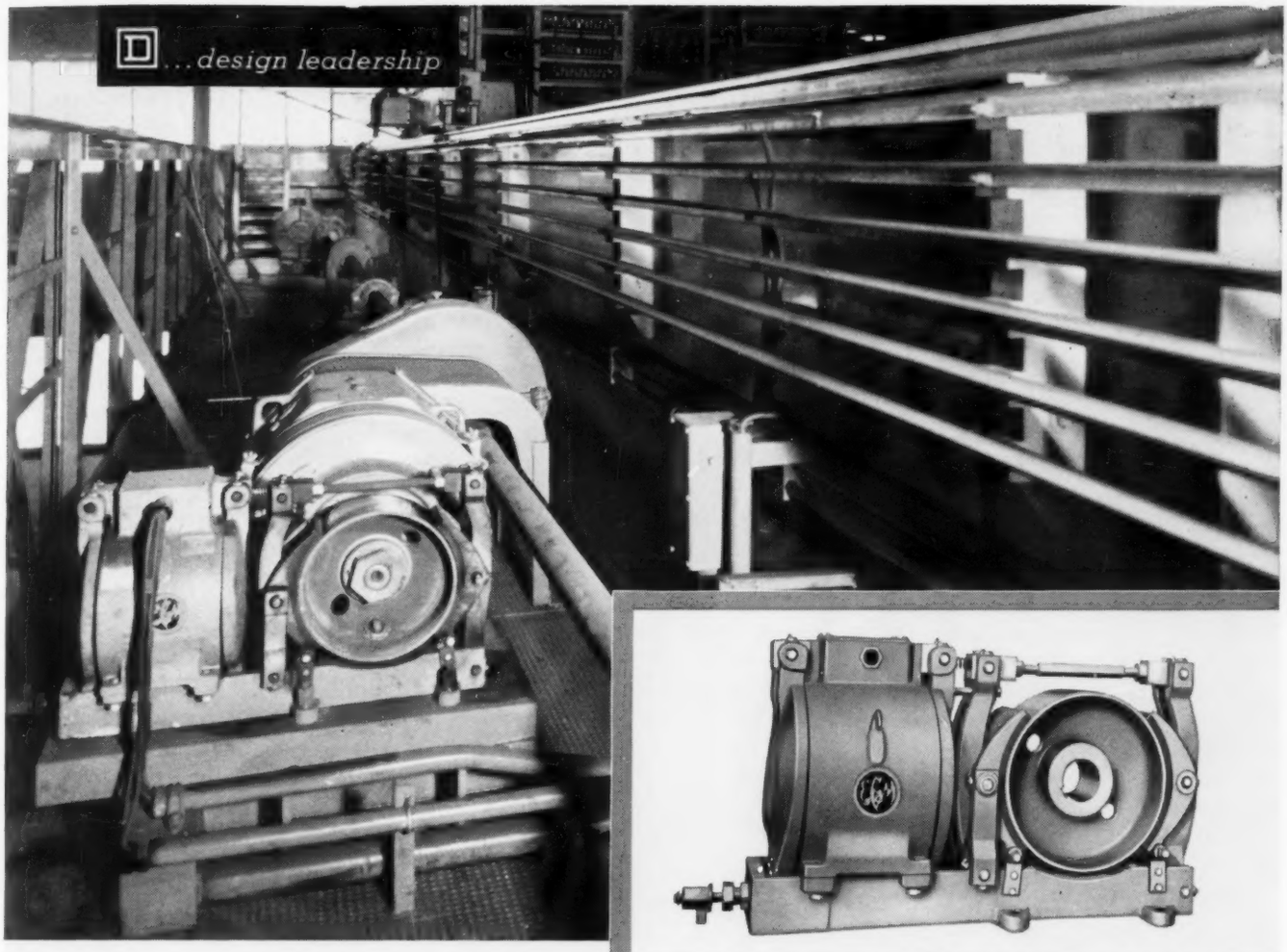
△ U. S. 2,959,406, issued Nov. 8, 1960 to Russell P. Heuer and assigned to General Refractories Co., provides an all-basic open hearth steel melting furnace with a heat recovery system which is capable of preheating the combustion air in the furnace burner when measured by an aspirator pyrometer during the refining period to an average temperature of 2490 F above the ambient temperature of the air.

The regeneration is carried out in two separate heat recovery units. The first one which employs basic refractories operates at high temperature and receives the exit gas when it first leaves the furnace, while the second one uses acid refractories and operates at lower temperature. The use of basic refractory brick in the high temperature regenerator avoids destructive attack of basic flue dust in the acid gases, and also permits higher operating temperature since the fusion temperature is higher. Also, in order to obtain a high operating temperature in the first regenerator, the size of the uptakes is restricted and the total weight of the regenerative brick in the basic regenerator is restricted.

After the exit gases leave the

Figure 3





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basic unit, their temperature may still be as high as 2200 F as determined by an aspirating pyrometer inserted in the moving gases, and in any case above 2000 F.

As shown in Figure 3, the exit gases enter at the top of the high temperature regenerator 34 and extend downward through the vertical passages on their way to the stack. The temperature of the exit gases as they pass over the regenerator bridge wall 33 and enter the high temperature regenerator will exceed 2600 F. As the exit gases pass through the vertical passages of the high temperature regenerator 34, it is desirable that the amount of heat absorbed by the checker brick shall be limited so that the exit gases from the high temperature regenerator which leave at 51 will at some time during the checker cycle reach about 2200 F.

The exit gases from the basic regenerator enter a refractory flue 52 which extends horizontally and connects with the bottom of acid refractory regenerator 53 consisting of acid refractory lateral walls 54 surrounding a chamber 55, an acid refractory grill supporting structure 56 at the bottom, and acid refractory roof 57 at the top and acid refractory checker brick 58 formed with vertical parallel flues. The acid refractory brick are suitably of fireclay. The acid refractory regenerator 53 permits the exit gases to pass upward through the checker flues to the exit stack. The size of the checker brick and the flues conform to conventional practice. The mass of the acid checker brick 58 should exceed $^2/_3$ of the total checker brick in the system consisting of one high temperature and one low temperature regenerator.

If desired, the height of the regenerator 53 can be reduced by adding a metallic or refractory recuperator at the cold end of the system. To illustrate this, a metallic recuperator 59 is shown having vertical steel tubes 60 through which the exit gases pass, connected in openings in tube sheets 61 and 62 at the opposite ends. The exit gas passing through the tubes in the recuperator is carried through a flue 63 to a blower and then to the stack. The incoming air passes through blower 64 and then through the space 65 around the tubes of the recuperator, and finally out through the flue 66 which connects with a horizontal cross flue 67, which communicates with valves 68 and 70 at opposite ends, and then joins beyond the valves a horizontal flue 71 which itself passes through opposite passages of the valves 68 and 70. The flue 71 communicates at the two ends with the top of the regenerator 53 at 72 and communicates at 73 with the top of the recuperator.

VACUUM TREATMENT OF MOLTEN STEEL

△ U. S. 2,959,478, issued Nov. 8, 1960 to Fritz Harders and assigned to Dortmund-Horder Huttenunion A.G., proposes that in the production of steel, the molten steel which interacts at normal pressure with the slag floating on it, should be subjected from time to time to a reduced pressure. This reduction in pressure results in a very vigorous release of the carbon monoxide reaction which is decisive for the course of the whole process and for the final quality of the product and which is greatly dependent on pressure. The manufacturing process of steel is consequently controlled in a way which has hitherto not been possible.

According to the invention, the melt, which is at normal pressure

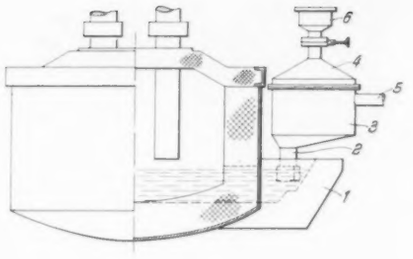

Figure 4

in any customary metallurgical furnace, is raised in portions into a vacuum vessel disposed above the furnace, and left there for some time at the most favorable reduced pressure and then returned to the melt remaining in the furnace. These operations are repeated until the metal beneath the slag is of the desired composition.

In Figure 4, the process is shown as carried out, for example, in an electric arc furnace. A Heroult-arc furnace 7 of the usual construction is equipped with a forehearth 1. A short pipe 2 leads from a vacuum vessel 3, which has a refractory lining and a cover 4 which has a vacuum tight seal, and extends into the forehearth. A suction pipe 5 leads to the vacuum pumps which are not shown. The reference 6 is a feeding device, e.g., for alloying materials. It is provided with an air lock.

When the pressure in the vacuum

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,956,320	10/18/60	Continuous casting of metal	Olin Mathieson Chemical Corp.
2,956,639	10/18/60	Coke oven gas naphthelene absorbing final cooler	Koppers Co., Inc.
2,957,432	10/25/60	Trolley for tong cranes	Koninklijke Nederlandsche Hoogovens en Staal-Fabrieken N.V.
2,957,812	10/25/60	Coloring stainless steel	Allegheny Ludlum Steel Corp.
2,958,520	11/1/60	Galvanizing furnace	Karl Fritz
2,958,521	11/1/60	High temperature coil annealing furnace	United States Steel Corp.
2,958,524	11/1/60	Electrical induction heating and quenching	Delapena & Son Ltd.
2,958,525	11/1/60	Bearing-chock balance	United States Steel Corp.
2,958,617-8	11/1/60	Hardening stainless steel	Armco Steel Corp.
2,959,409	11/8/60	Cupola furnaces	J. W. Jackman & Co. Ltd.
2,959,506	11/8/60	Low alloy high tensile strength high impact strength steel	Secretary of the Army
2,959,555	11/8/60	Copper and iron containing scale removal from ferrous metal	The Dow Chemical Co.
2,959,630	11/8/60	Electric arc reduction furnace	Demag-Elektrometallurgie G.m.b.H.
2,959,992	11/15/60	Master control device for rolling mills	Granite City Steel Co.
2,690,330	11/15/60	Cupola furnace for producing iron having a predetermined carbon content	Strico Gesellschaft fur Metallurgie und Warmetechnik m.b.H.
2,960,391	11/15/60	Regeneration of spent pickle liquor	Singmaster & Breyer, Inc.
2,960,396	11/15/60	Pelletization of iron ore concentrates	P-M Associates
2,960,421	11/15/60	Elimination of white layer in nitrided steel	National Broach & Machine Co.

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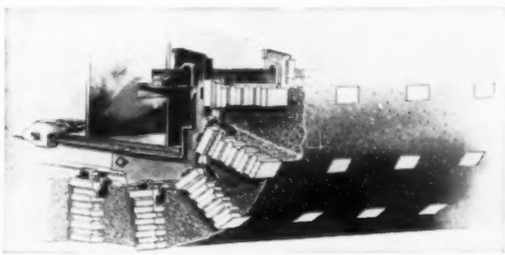

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vessel 3 is lowered, a portion of the melt in the arc furnace is drawn through the pipe 2 into the vacuum vessel 3. The melt is returned to the charge remaining in the arc furnace, for example, by altering the pressure in the vacuum vessel. When the pressure is then again reduced, a fresh portion of the melt enters the vacuum vessel and undergoes the same treatment. Alternatively, one may fill and empty the vacuum vessel by altering the level of the vessel while maintaining the vacuum in it. At the great speed with which the carbon-oxygen reaction proceeds, the intermediate vacuum treatment of the metal takes place very rapidly. For example, it can be carried out in $^3/_4$ min, including the raising and lowering of the vessel, when the pressure is in the region of 1 to 10 mm Hg. In the case where the vacuum vessel has, for example, one-tenth the capacity of the furnace, then the vacuum treatment of the entire melt is completed in $7^1/_2$ min. Owing to the backward and forward flow which it produces, the vacuum vessel functions at the same time as a kind of stirring apparatus.

If the pipe 2 is of an appropriate shape, the forehearth can be dispensed with and the pipe 2 leading off from the vacuum vessel can in that case be passed through a door of the furnace.

Owing to the great dependence of the carbon monoxide reaction on pressure, it is possible to obtain, according to the degree of vacuum used, a very low content in carbon together with very low oxygen contents. In such cases, the vacuum apparatus can at the same time be used as a measuring instrument. As long as there is an excess of carbon in the melt, addition of oxygen causes carbon monoxide to be given off, and this leads to a measurable increase in pressure. The same reaction takes place when carbon is added in the presence of excess oxygen.

It is no longer necessary to preheat additions and alloying constituents to protect the steel from taking up of hydrogen. Similarly, owing to the vigorous vacuum degasification, it is unnecessary to carry out the refining step which is normally carried out on remelting charges in some cases, merely for the purpose of removing gas, in particular hydrogen.

Inexpensive alloy carriers, which have a high carbon content, may also be used when the final product is required to have a very low carbon content. If appropriately low pressures are employed, the carbon can be refined out, in the presence of almost any alloying elements without these elements slagging. This refining may be done, for example, by introducing ores into the vacuum vessel. This is also of particular importance for highly alloyed remelting charges with a particularly low final carbon content, the production of which in a vacuum plant with an arc furnace coupled to it provides no difficulty.

ALUMINUM EVAPORATED COATING ON STEEL SHEET

△ U. S. 2,959,494, issued Nov. 8, 1960 to George A. Shepard and assigned to Republic Steel Corp., provides a method for preparing steel sheet for the vacuum coating of aluminum.

Figure 5 shows a system of cleaning a strip of steel sheet for aluminum deposition. This steel sheet may be any suitable steel such as black steel plate used in tin plating. A tank 10 is provided with a solution of a cleaning composition for first cleaning the sheet 25 in a soak-cleaning.

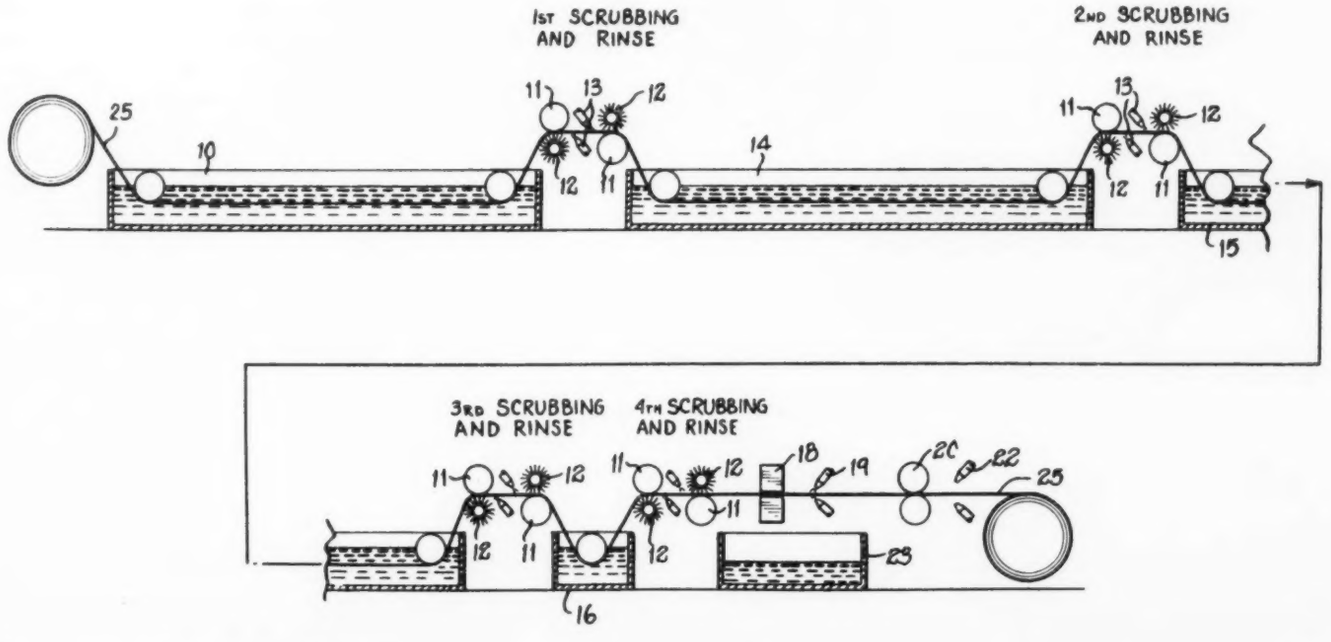
The sheet 25 is cleaned in this soak-cleaner solution of tank 10 for 5 min at 205 F.

Following the first scrubbing, the sheet 25 is subjected to a cathodic electro-cleaning in a tank 14 for 1 min at 205 F.

In this electro-cleaning step, the sheet 25 is electrically connected as a cathode in the tank 14 and subjected to a current of 30 to 50 amp per sq ft of stripped area in the bath.

After electro-cleaning, the sheet 25 is subjected to scrubbing. Between scrubbing the lower surface and the upper surface, pairs of nozzles 13 spray both the upper and lower surfaces to provide a rinsing action. Following the second

Figure 5



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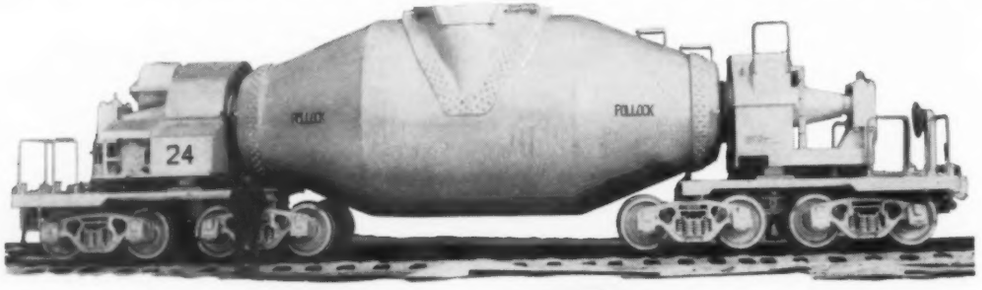

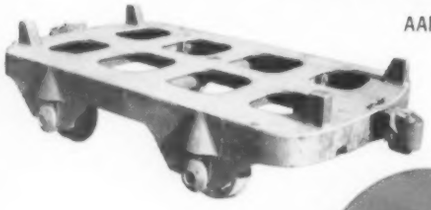

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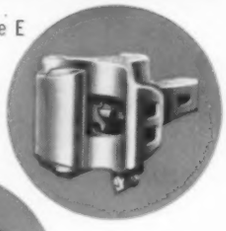

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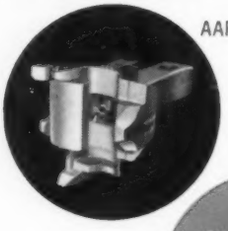

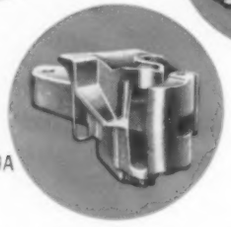

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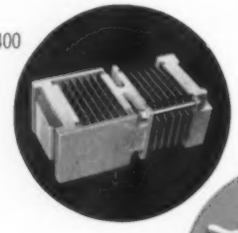

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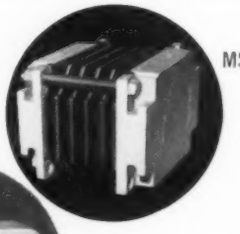

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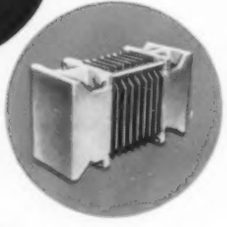

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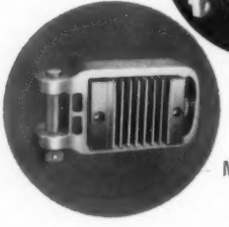

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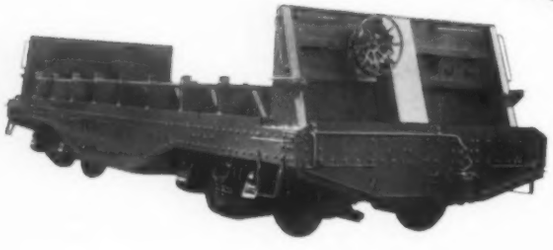

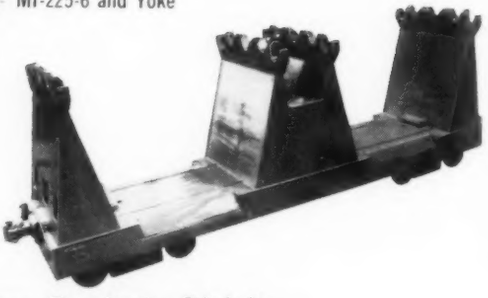

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scrubbing and rinsing, the sheet 25 is treated with a muriatic acid pickling in a tank 15. The muriatic acid pickling solution is a hydrochloric solution ranging from 15 to 30 per cent in concentration. The concentration of the acid solution and the time of immersion of the sheet 25 vary with the degree of soil or oxide on the sheet and the agitation of the solution. A 15-sec dip is effective. Following the acid pickling, the sheet is subjected to the third scrubbing and rinsing. Rotary brush 12, paired against the backup roll 11, brushes the lower surface of the sheet 25 followed by the rinsing of both surfaces from a pair of nozzles 13. The rotary brush 12, paired against the backup roll 11, scrubs the upper surface of the sheet 25.

To obtain a satisfactory adherence of vapor deposited aluminum on the sheet 25 surfaces, the sheet is next subjected to an additional soak step in a tank 16 to provide the steel sheet surface with a passivity which inhibits or prevents reoxidation.

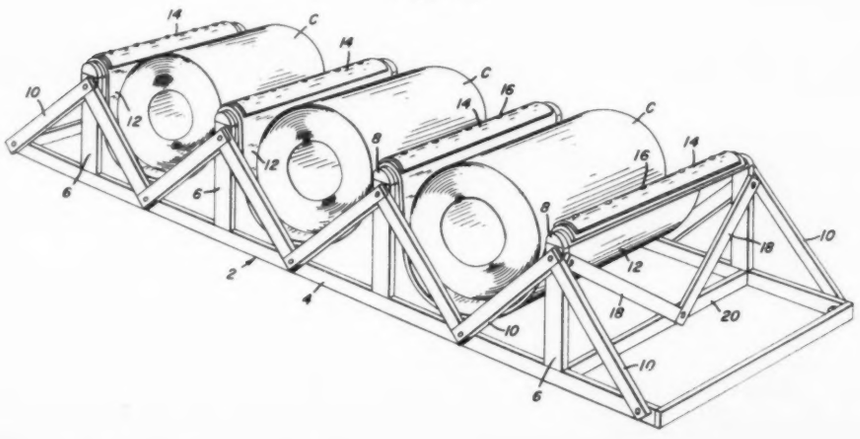
COIL CARRIER

△ U. S. 2,958,492, issued Nov. 1, 1960 to Theron W. Maynard and assigned to United States Steel Corp., provides a sling-type carrier for coiled material in transit.

In Figure 6, numeral 2 designates the carrier frame of the invention, which includes a base 4 and a number of pairs of spaced vertical upright supports 6 which project upwardly from the base 4. A beam 8 is connected with and extends between the upright supports in each pair transversely of the base 4. Braces 10 are connected with and extend angularly between the upper portion of each of the upright supports 6 and the base 4.

In operation, the frame 2 is first anchored securely to the floor of a transport vehicle such as a gondola, highway truck or similar vehicle, the coils C are then loaded onto the slings 12 by means of an overhead crane, a fork-lift truck or other similar means. Upon arrival at destination, the coils are removed from the slings by an overhead crane, fork-lift truck or similar means whereupon the coil carrier of the invention may be returned to the shipper or it may be retained by the consignee and used as a storage unit for the coiled material.

Figure 6



COIL CARRIER WITH PNEUMATIC COIL SUPPORT

△ U. S. 2,958,493, issued Nov. 1, 1960 to James E. Ashworth and assigned to United States Steel Corp., provides an apparatus for handling bundles of coiled material.

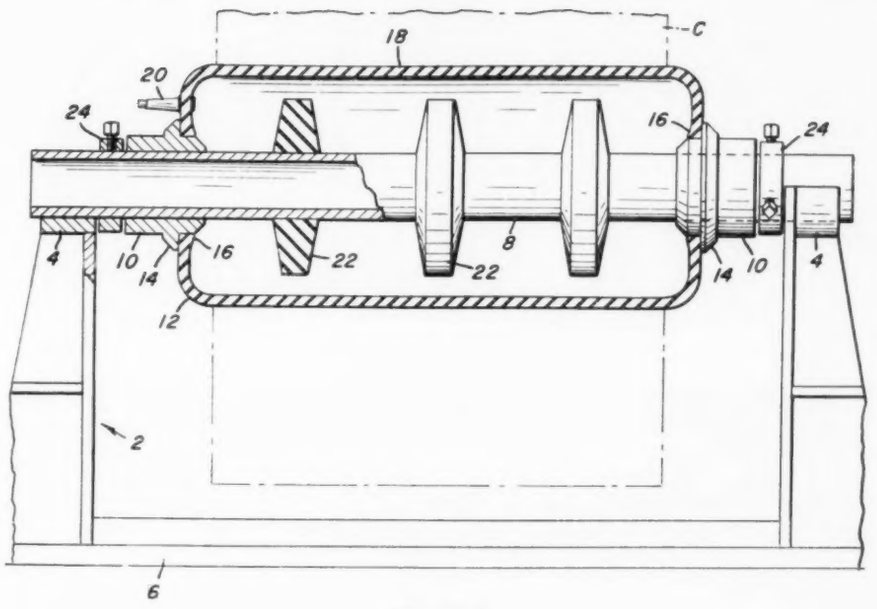


Figure 7

In Figure 7, reference numeral 2 designates the coil cradle of the invention which includes two spaced upright bearings 4 mounted on a base 6. Reference numeral 8 designates the shaft or mandrel of the invention which may be made in the form of a light weight, high strength metal tube adapted to be supported on the upright bearings 4. Spaced collars or rims 10 are disposed on the shaft 8 for mounting an expansible sleeve or tube 12 on the shaft 8. Each of the collars 10 is formed with a flange 14 which forms an inner seat on the collar for receiving the beads 16 of tube 12.

In operation, the shaft 8 with the tube 12 mounted on it in deflated condition is fitted into the eye of a coil C of strip material which is to be transported. After the shaft and tube have been thus inserted into the coil, the tube 12 is inflated so that the tread 18 thereof engages and supports the inner circumference of the coil. The shaft 8 is then seated in the bearings 4 by means of an overhead crane, fork-lift truck, or similar means. The cradle 2 is rigidly mounted on the floor of a carrier such as a gondola, highway truck, or other transport vehicle.

The cushion of air provided by the inflated tube 12 upon which the carrier rests during transportation minimizes shock to the coil caused by transportation movements thereby reducing the possibility of damage due to vibration.

From RCA The Most Trusted Name In Electronics

RCA 110 Electronic

Engineered to withstand the rigors of industrial environment...an ultra high-speed control system ...tailored to your exact needs

The RCA 110, an advanced solid state industrial computer, offers capabilities that range from simple automatic monitoring and recording to complete real-time computer control of complex industrial operations.

From its very concept, the RCA 110 was designed for continuously operating processes, and built for maximum effectiveness under the hardest industrial usage. It is housed in dust-tight heavy steel cabinets and air-cooled by internal heat exchangers to guard against contamination from outside atmosphere. The entire system is programmed so that it will continuously check itself. In the event of main power failure, the RCA 110 calls into action a "safe shutdown" sequence without loss of computer memory or instability to the controlled system. Wired-in priority interrupt helps make the RCA 110 the most efficient industrial computer offered anywhere.

Like all RCA Electronic Data Processing Systems, the "building-block" concept of the RCA 110 permits custom-assembly of the system according to your special requirements, and easy expansion as your needs demand.

For detailed information on the world's most advanced industrial control computer, ask your nearest representative of the Foxboro Company, or write —Industrial Computer Systems Dept., Electronic Data Processing Division, RADIO CORPORATION OF AMERICA, 21 Strathmore Road, Natick, Mass.

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

6 REASONS WHY THE RCA 110 IS THE WORLD'S MOST EFFICIENT

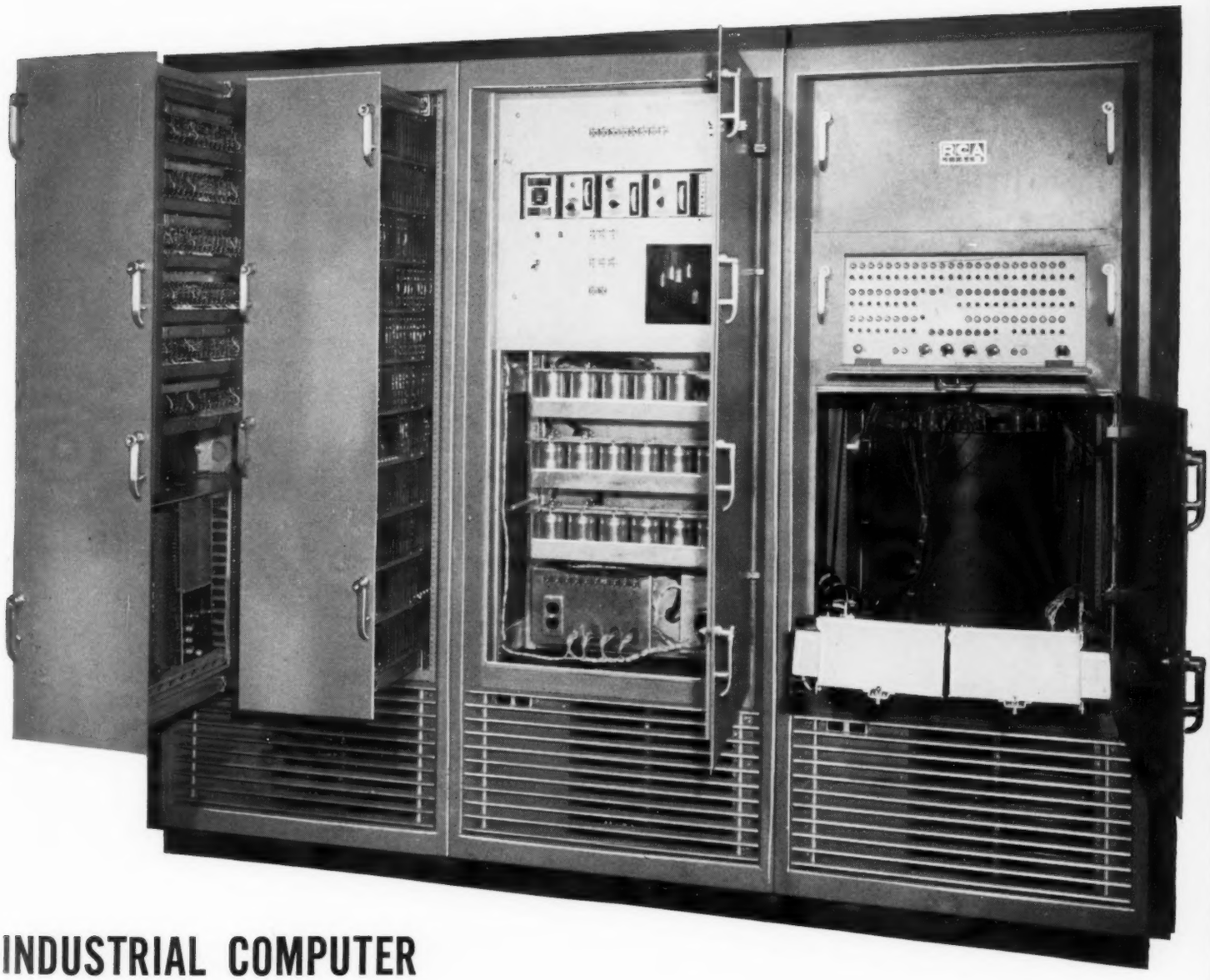
DESIGNED FOR FAIL-SAFE CONTINUOUS OPERATION even under the most exacting factory conditions. Dust-tight, heavy-duty all-steel enclosures are equipped with industrial heat exchangers for internal cooling to prevent contamination from outside atmosphere. Requires no false flooring or other special site preparations.

UNIQUE PRIORITY INTERRUPT FEATURE enables computer to automatically select the most urgent task from multiple demands. Operates on programmed priority basis, to avoid traffic jams and to handle emergency situations immediately. Result—programs are easier to write, memory space is conserved, and computer free time is automatically assigned to self-checking routines.

MAXIMUM SYSTEM ACCURACY IS SAFEGUARDED with low impedance, single path ground scheme—permits low level signals to be processed by computer, eliminating cross talk interference from main frame currents. Employs solid copper, 150 pound bus bar as integral part of grounding system.

HEAVY DUTY SOLID STATE POWER SUPPLY includes separate metering and adjustment of all DC voltages, automatic alarming of over-voltage, and circuit breaker protection against current overload. Motor driven control eliminates start-up shock and prolongs life of all components. Reserve capacities in power supply, plus priority interrupt routine, safeguard memory information, and safely shut down the computer in event of main power failure. Entire system sectioned and metered for high-speed, automatic check-out.

Industrial Computer System



INDUSTRIAL COMPUTER

EASY MAINTENANCE EVEN DURING OPERATION—all circuits accessible from front in extendable drawers and hinged chassis. Industry's most complete maintenance panel permits manual check-out of complete system. Computer continues to operate with all drawers fully extended. Circuits are designed to perform at high temperatures—have built-in marginal testing, and an automatic alarm signals improper operating voltages.

MODULAR DESIGN PERMITS FIELD EXPANDABILITY — both drum and core memories can be expanded in the field within a few hours as additional tasks are assigned to the computer or the number of inputs, outputs, and data manipulations are increased.

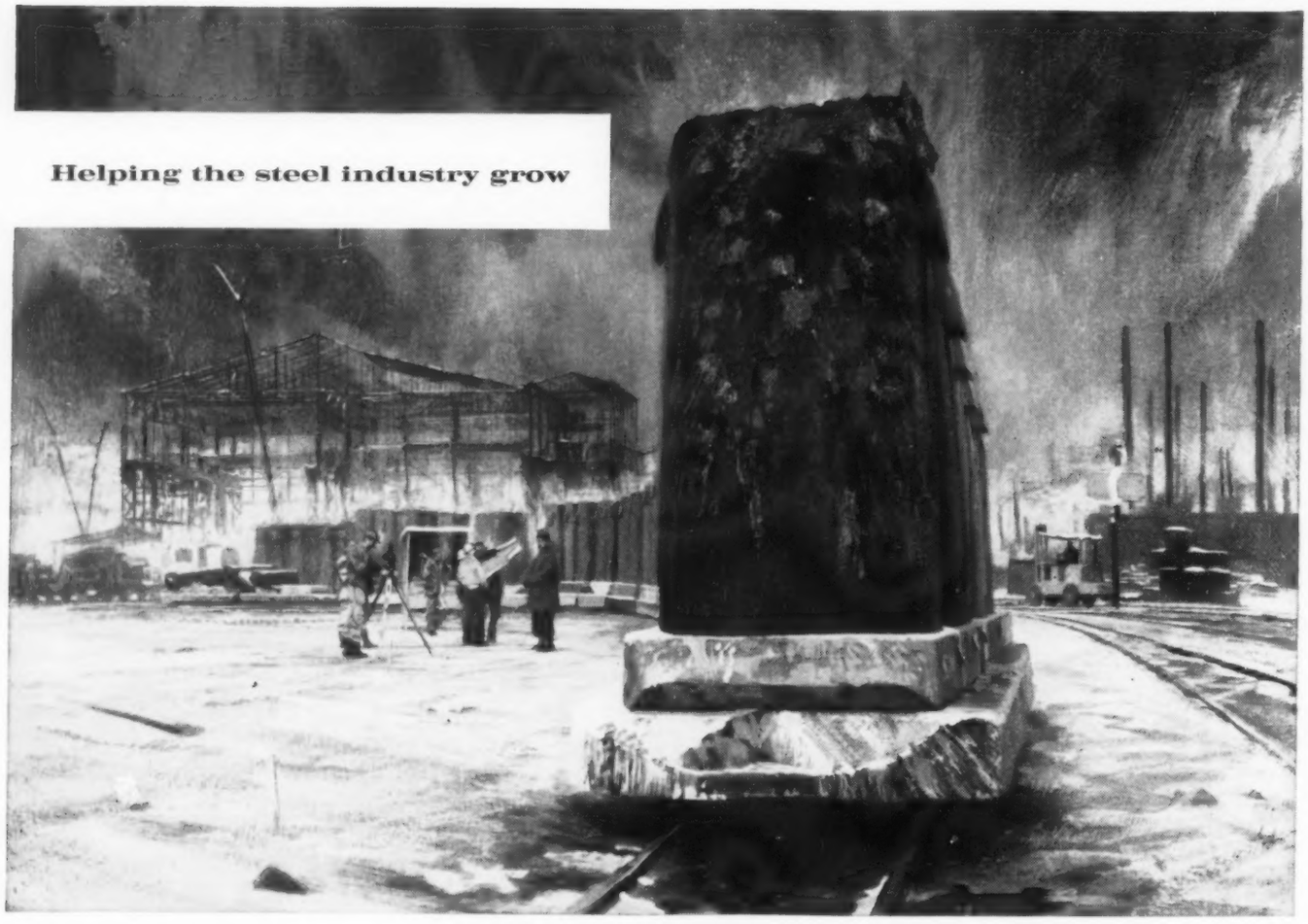
COMPARE THESE PERFORMANCE SPECS

Speed — including access time and staticizing, adds in 56 microseconds, multiplies in 728, divides in 868. *Instructions*—one address (limited two address), 7 indexable address registers, 71 wired-in instructions. *Number System*—fixed point, binary or binary coded decimal. 24 bit word length, word time 28.89 microseconds. *Working Storage*—magnetic core, coincident current, variable in size from 256 to 4096 words, 8 high-speed input-output registers, clock frequency 936 kilocycles. *Bulk Storage* — magnetic drum, 3600 rpm, 4096 to 51,200 words, 8.3 milliseconds average access time, 200 kilocycle transfer rate, up to 12 buffer tracks for input-output. *Size*—82" high, 34" deep, 105" long. *Typical Power Input*—5 kva, 220 volts.

River of steel on rails

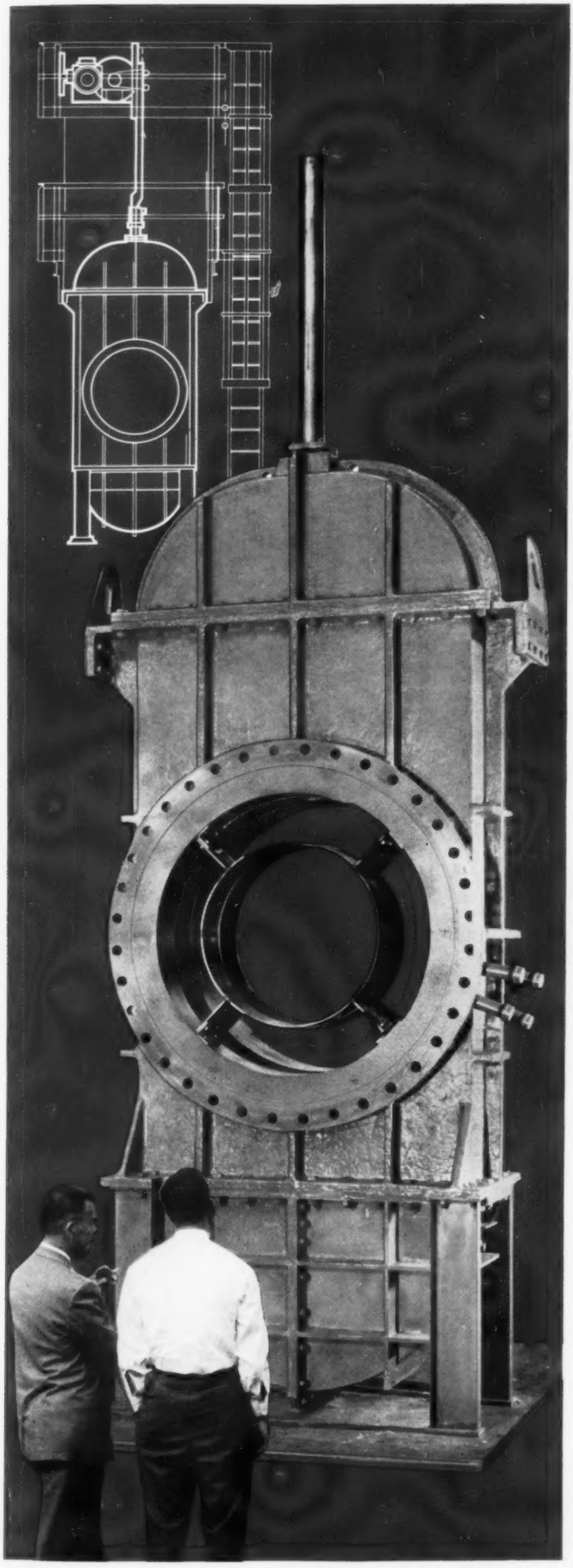
Giant molds, filled with cherry-red molten steel, roll past a nearly completed electric furnace plant en route to the stripper. United Engineers has served many of the country's leading steel producers on projects of widest scope—designing and installing such facilities as rolling mills, slab heating furnaces, sintering strands, desulfurizer stations, oxygen plants, power plants, and coal handling equipment. Each project demonstrates the time and cost-saving advantages in our coordination of design, purchasing, expediting and construction. We invite you to profit from our background of over 75 years' experience as designers, construction engineers, and engineering consultants.

Painting by Stanley Meltzoff



UNITED ENGINEERS

& Constructors Inc. • U.E.&C. (Canada) Ltd. • New York • PHILADELPHIA • Chicago



NEW

fastest way of changing blast furnace stoves

BAILEY

WATER-COOLED GAS BURNER SHUT OFF VALVE

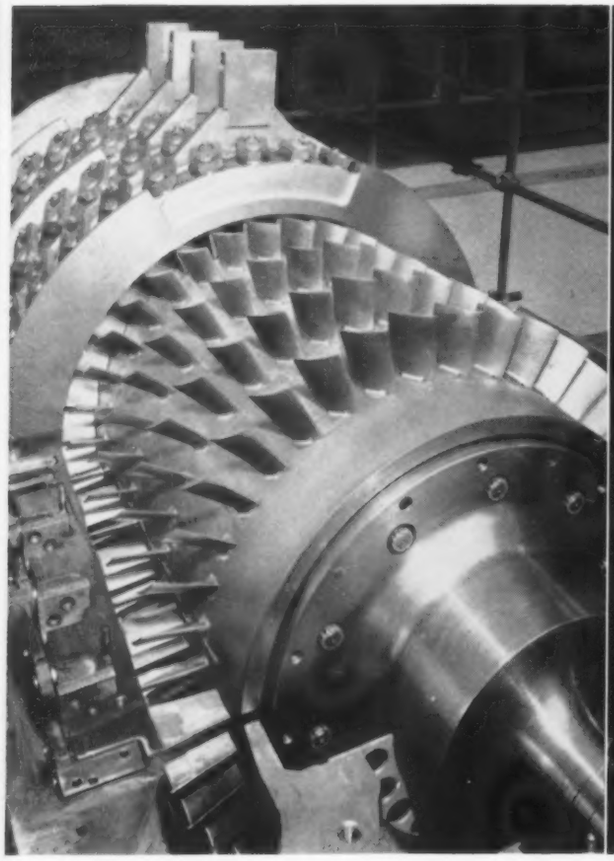
Full Open to Full Closed in 11 Seconds

Valve disc and body are water cooled to prevent overheating while the stove is on blast. Motor-operated drive unit is located on a platform above the valve, well clear of stove heat. This valve is bolted tight to the burner and stove saddle flange, thus preventing leaks at the burner. *Write for Bulletin GB-100.*

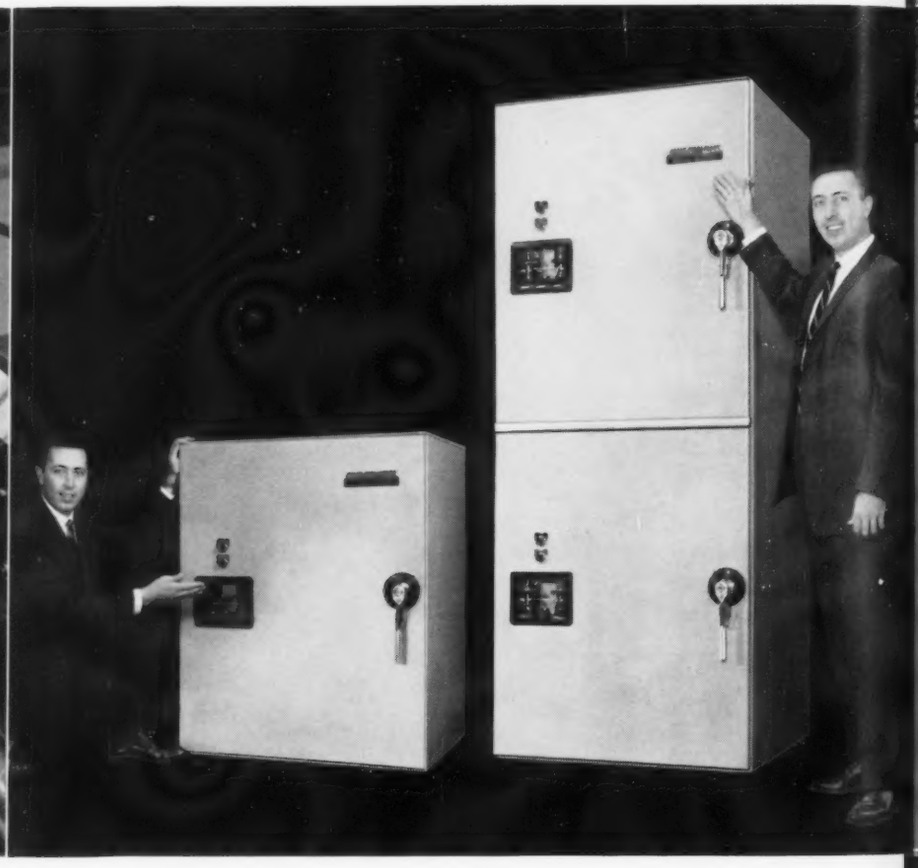
WILLIAM M. BAILEY COMPANY

1221 BANKSVILLE ROAD, PITTSBURGH 16, PA.

ideas and news:



Fully adjustable stator blade control: Extends range of highly efficient axial compressors. Combines ability to meet fluctuating demands at constant speed with basic axial design advantages . . . steam savings of over 10%, and space and weight savings 25 to 50% of that required by comparable centrifugal compressors.



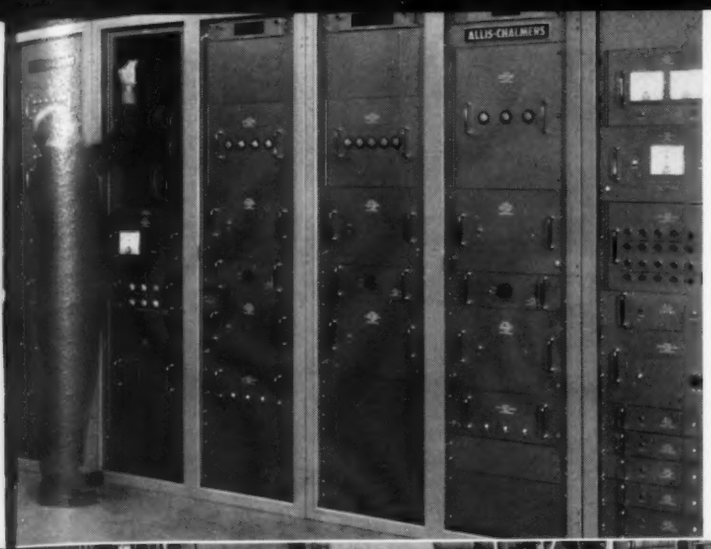
So low, two fit where one used to go: This new SpaceMaker control center is the first completely new 2- to 5-kv motor controller in more than a decade. Two-high design can cut floor space requirements in half. Complete drawout construction makes it the safest, most easily accessible controller on the market. New flame-retardent, track-resistant Super Pyro-Shield insulation adds to reliability, reduces size and weight. And, the all-new roll-out contactor is designed to cut maintenance time.

Which of these productive ideas could be working for you?

Screens that can't blind. Compressors with adjustable capacity at constant speed. These examples demonstrate the extra value that is standard with Allis-Chalmers . . . the greater efficiency and the added productivity which are yours when you buy A-C products, systems and services. Call your Allis-Chalmers representative for details on A-C "worth-more" features. Or write Allis-Chalmers, Industrial Equipment Division, 900 S. 70th Street, Milwaukee 1, Wisconsin.

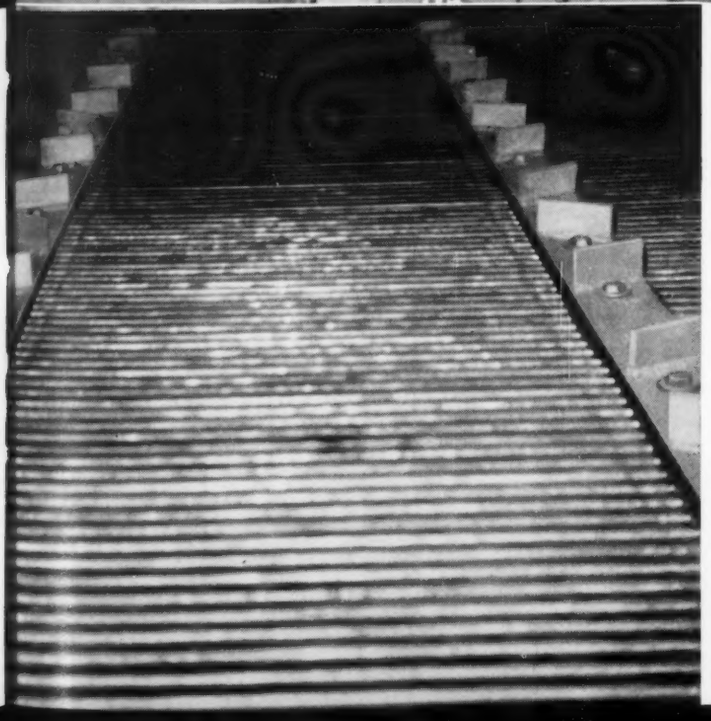
A-1399

Systemation is an Allis-Chalmers servicemark. *SpaceMaker* and *Pyro-Shield* are Allis-Chalmers trademarks.



For quality control . . . lower processing costs: Systemation engineers at Allis-Chalmers will undertake responsibility for the design of complete operating facilities. Systemation service is based on a thorough understanding of your processing requirements gained from years as a major equipment supplier to your industry. Added is the experience of over 500 successful advanced electronic control systems by Consolidated Systems Corporation, an affiliate company.

Sixty-eight motors power plating rolls: When this electrolytic tin line went into operation in 1960, 68 Allis-Chalmers totally-enclosed fan-cooled dc gearmotors powered the plating rolls. Additional Allis-Chalmers motors and supporting motor-generator sets provide power throughout the line. Whether small process line drives such as these, or huge main mill drives, A-C motors have earned a reputation for long life and trouble-free operation.



Screen moist, sticky ores without blinding: Allis-Chalmers new loose-rod deck for vibrating screens makes finer separations — down to ⅜ or ¼ in. — at increased capacity and improved efficiency. The rods roll and bounce, freeing themselves of sticky material. Similar cost-saving advantages are also found in A-C hot sinter screens and sizing screens.

A-C INDUSTRIAL EQUIPMENT DIVISION: motors, generators, controls, rectifiers, pumps, compressors, grinding mills, screens, industrial systems.

OTHER A-C PRODUCTS: thermal, hydro and atomic electrical generating equipment; switchgear, transformers, unit substations; tractors, earth-moving equipment, engines, lift trucks.

ALLIS-CHALMERS

WHY THE TREND IS TO

Taylor Electronic Control

. . . Because the Taylor TRANSCOPE® Electronic System utilizes the inherent speed of electronic circuits to a greater degree than any other process control system and delivers unparalleled performance. The unique response characterisitics of the 700R Controller overcome the effects of "reset wind-up", eliminate overpeaking on critical start-ups and even after large load changes.

The Servo powered 700J Recorder, gives greater recording accuracy than previously available, and the Servomatic motor provides the necessary power for precision operation of auxiliary mechanisms and computing devices. A complete line of transmitters provide rapid sensing and transmission of temperature, pressure, flow and other variables.

Ask your Taylor Field Engineer for a demonstration, or write for **Bulletin 98335.** Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ontario.

AC or DC RECORDER

TRANSCOPE 700J Recorder incorporates a true 2-phase servo motor, sensitive to changes of 0.1% in the input signal yet providing 1,000 times more power than a galvanometer system for pen positioning and auxiliary functions. Accuracy is ½ of 1% (0.25% optional). Completely transistorized, the 700J is unaffected by line voltage changes ±10%. Available for 0-200 mv AC or 1-5 ma DC transmission.

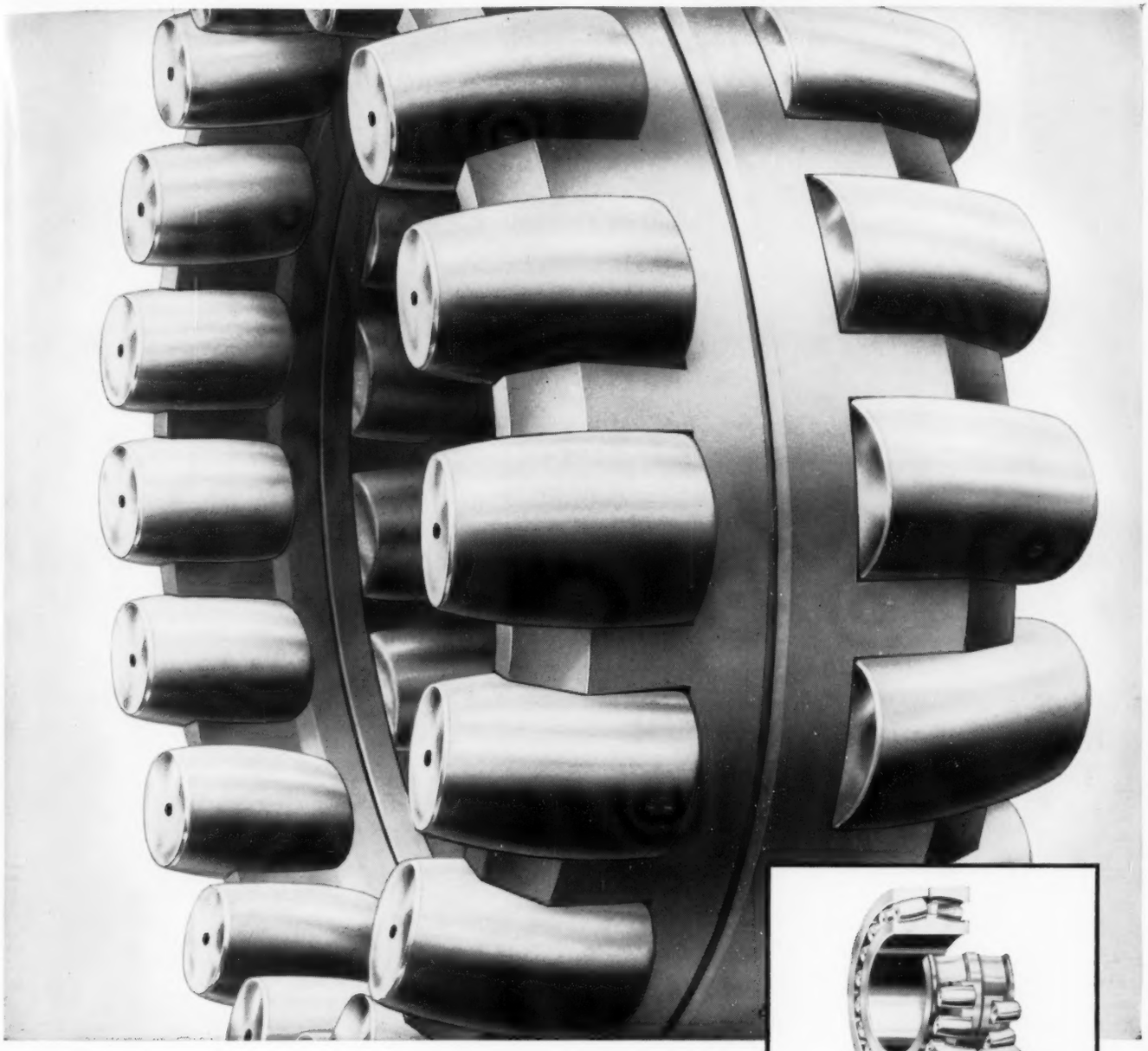
All principal assemblies and sub-assemblies plug in for flexibility, easy servicing. Recorder slide can be removed without disturbing process control. Control settings available from the front of the recorder. Available with 1, 2 or 3 pen recording.

AC or DC CONTROLLER

TRANSCOPE 700R Controller embodies all the advantages of the most advanced control circuits. The unique diode limiter circuit permits even the two-response controllers to eliminate overpeaking. It is effective *at all times,* whether the variable is approaching control point from *above* or *below;* on changes in set point; following major process disturbances; or on start-up.

Interchangeable, plug-in assemblies permit conversion to either fast or standard reset and two-response or three-response controllers. Unaffected by line voltage changes up to ±10%. Output signal from 1-5 Ma feeds into any load from 0-10,000 Ohms.

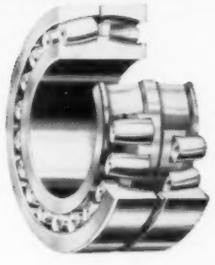
Taylor Instruments MEAN ACCURACY FIRST



"Caged" for Longer Life!

The two land-riding cages in Torrington Spherical Roller Bearings assure proper roller spacing and guidance, even under rugged conditions of shock load and sustained high speeds. These fully machined cast bronze cages operate independently. Their design eliminates drag on rollers. These high-strength cages help bearings give longer life by providing low friction, smooth running and cool operation. Highly effective and generous lubrication of all contact surfaces is achieved with the open-end cage design.

The result: Torrington Spherical Roller Bearings are built to give extra years of unmatched service life in heavy-duty applications. Torrington's long experience in design, engineering and manufacture of every basic type of anti-friction bearing provides the finest spherical roller bearings available. You'll find it pays to standardize on Torrington.



Superior design features of TORRINGTON SPHERICAL ROLLER BEARINGS

- integral guide flange for roller stability
- asymmetrical rollers seek flange for positive guidance
- electronically matched rollers
- size-stabilized races
- fully machined land-riding bronze cages
- controlled internal clearances
- even load distribution
- inherent self-alignment
- long service life

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

949 tons of tin product rolled in 8

This mark tells you a product is made of modern, dependable Steel.

8 hours—on USS Quality Forged Rolls

THE MAN IN THE SMALL PICTURE is Charles D. Kelly, Superintendent of the cold reduction and sheet finishing department at U. S. Steel's giant Fairless Works. He was completing his 20th year when a crew on the 5-stand cold reduction mill rolled out an impressive 949 tons of tin product in a single 8-hour shift.

The mill was equipped with USS Quality Forged and hardened rolls, as might be expected. But you should know that no U. S. Steel mill is obligated to buy rolls from the company if competitive rolls will give better performance. Here is the heart of the story: based on careful long-range performance figures, the USS forged rolls are equal to or better than any other on the market.

As a major steel producer, U. S. Steel has the opportunity to test the quality of its rolls. Even further, U. S. Steel buys rolls from other manufacturers—for an evaluation of our product. Over and over again, records have shown that USS Quality Forged Rolls have improved wear resistance, and a high degree of cleanliness.

When buying most custom-made steel products, the customer specifies the quality, type and chemistry of the steel, as well as heat-treating procedures and other manufacturing methods. Not so with rolls. With the exception of physical dimensions, surface finish and hardness level, rolls are sold strictly on the basis of performance. Do you keep a careful record of your roll performance? If you do, you may well find yourself ordering USS Quality Forging rolls *all* the time.

Please address inquiries or requests for our free 32-page Forging booklet to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

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United States Steel Corporation—Pittsburgh
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USS

How much OXYGEN do you use..*and where?*

KNOW.. accurately..with Bailey O_2 Flow Transmitters

Why wonder about oxygen consumption and costs in steelmaking applications?

Bailey O_2 Flow Transmitters—either square-root or square-root extracting types—provide constant, accurate metering of oxygen use for better cost records and product quality control.

Bailey Force Balance Flow Transmitters produce a *linear* signal of flow which can be recorded—and integrated—on uniformly graduated scales or charts. This signal is also used in control applications. Linear signals are made possible by a square-root extractor integral with transmitter—the only transmitter with this feature.

Bailey Force Balance Differential Transmitters produce non-linear signals of flow to a recorder, integrator, and/or controller.

Bailey O_2 Flow Transmitters are now in successful operation in leading steel mills. They are supplied in a wide selection of ranges which may be readily adjusted. Ask for complete product specifications—specify Bailey Flow Transmitters on your next order for distribution meters.

S119-1

IRON AND STEEL DIVISION

BAILEY METER COMPANY

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BAILEY METERS

BLAW-KNOX

Hot Strip Mills

Blaw-Knox designs and builds a full range of continuous, semi-continuous and single stand reversing hot strip mills. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals, sheet and strip processing equipment, electrolytic tinning, annealing, and galvanizing lines, seamless pipe and tube mills, draw benches, and cold draw equipment, Blaw-Knox Medart cold finishing equipment, iron, alloy iron and steel rolls, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings. Blaw-Knox Company, Foundry and Mill Machinery Division, Blaw-Knox Building, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

56-inch semi-continuous hot strip mill.

FOR YOUR WETTEST JOBS

Wagner® Silicone Rubber Insulated Motors

Power-packed drip-proof polyphase motors that are exceptionally moisture-resistant . . . save you money in lower initial equipment cost for many applications

These are motors that are built to take on and tame the toughest jobs. Big, job-rated motors, available in frames larger than 445U, through 1000 horsepower. Perfect drives that can be used for station auxiliaries, in chemical plants, in rubber and paper mills and in the petroleum industry.

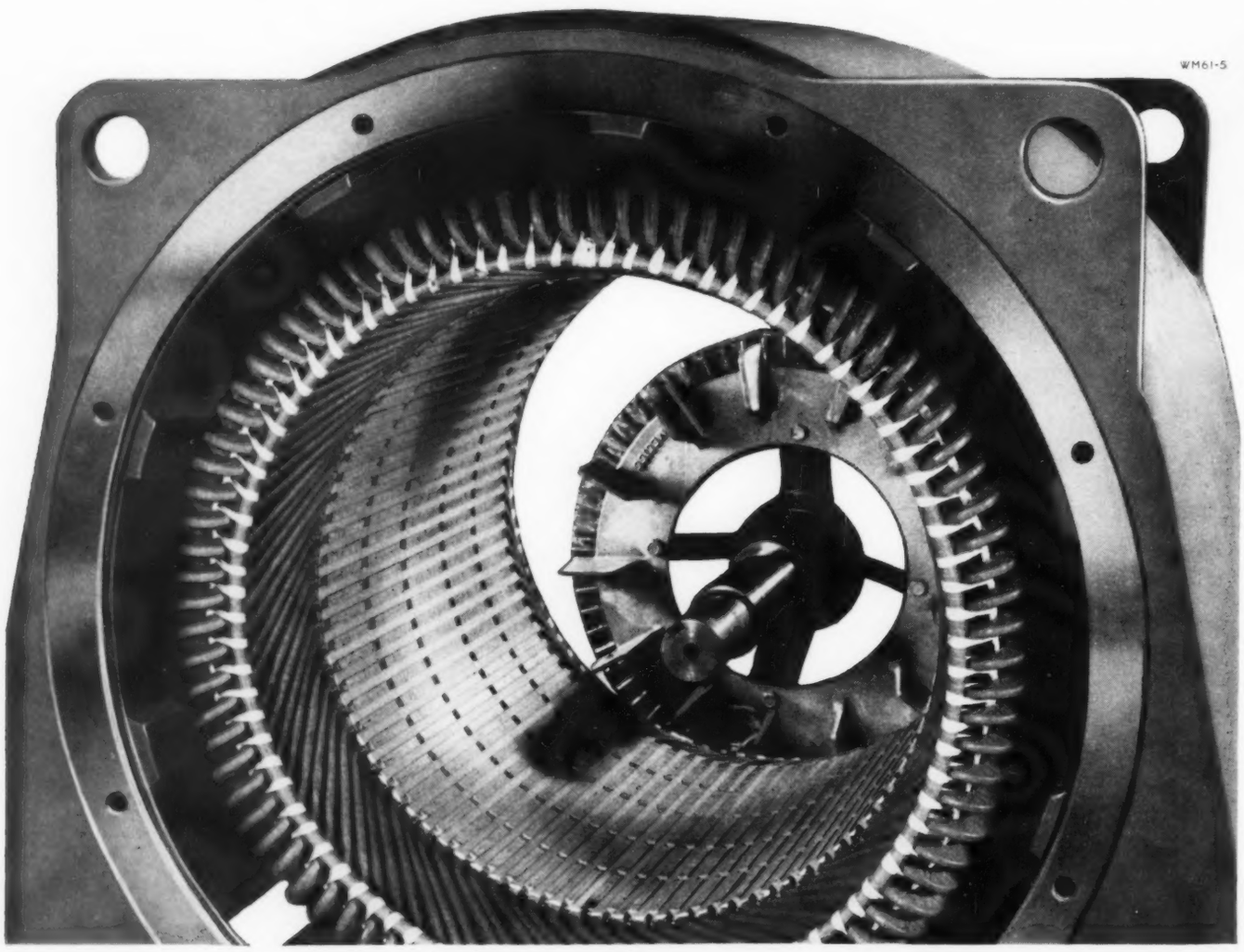
With motor coils completely sealed in a jacket of silicone rubber and housed in a compact, drip-proof enclosure, these Wagner® motors are suitable for use in highly humid atmospheres. They perform perfectly even after long exposure, and at elevated temperatures. Since moisture does not penetrate their tough silicone jackets, they are now used for many installations that once required totally-enclosed motors. Silicone rubber insulated motors cost less to buy than equivalent totally-enclosed fan cooled motors, since there is no need for expensive enclosures.

But your savings don't stop with initial cost. When rated to match normal load, Wagner silicone rubber insulated motors deliver rated horsepower at top efficiency. They have more overload capacity for temporary overloads . . . reduce downtime while they help keep production levels up.

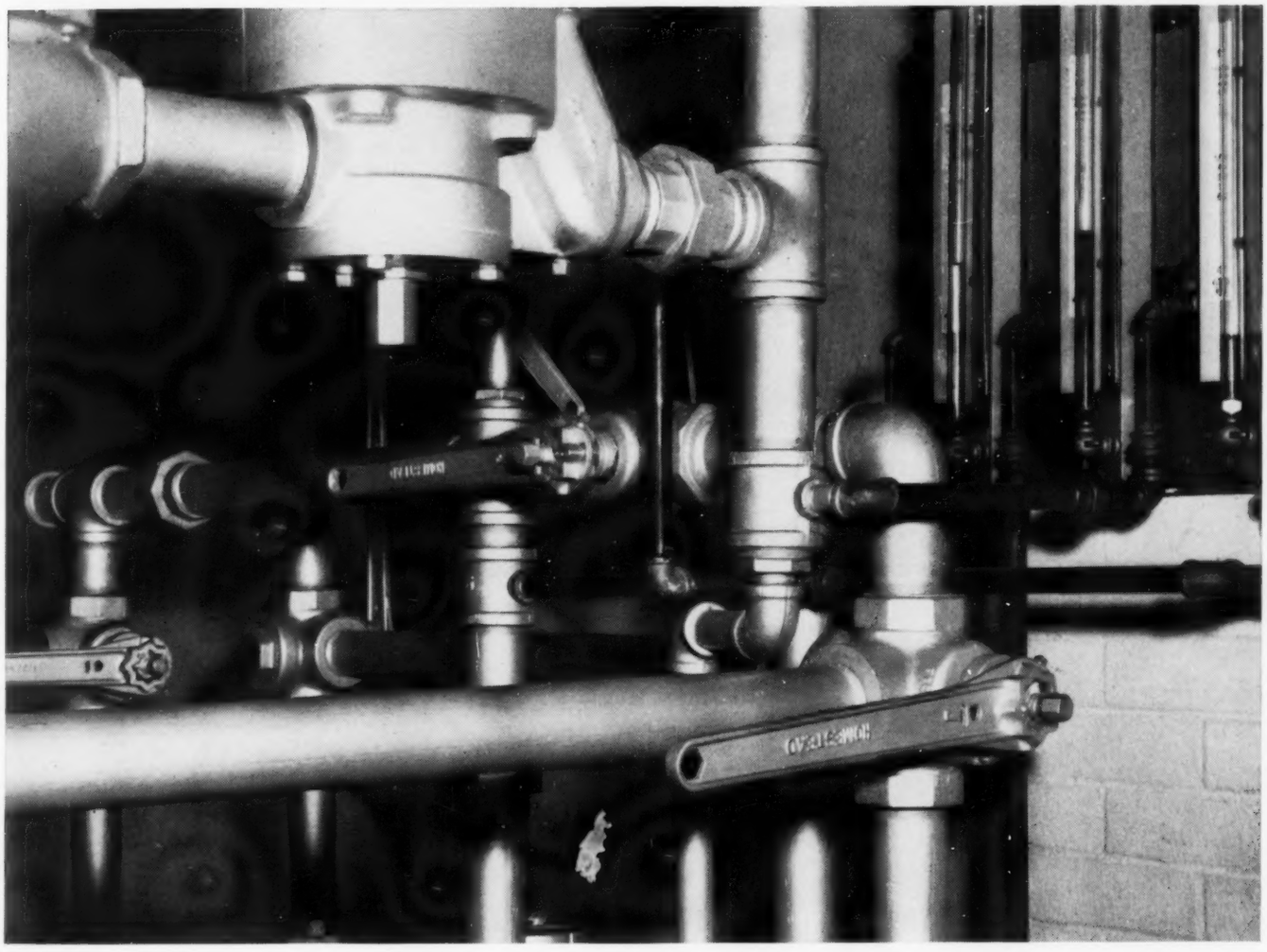
Like to hear the whole money-saving story of these dependable Wagner silicone rubber insulated motors? Call your Wagner Sales Engineer . . . then settle back for some profitable listening.

Wagner Electric Corporation

6483 PLYMOUTH AVENUE, ST. LOUIS 33, MO., U.S.A.



CLOSE TOLERANCE—KEYNOTE TO LOW-COST MAINTENANCE—is yours with Homestead® Lubricated Plug Valves. Vital to efficient fluid control, this close tolerance between sealing surfaces



(.002″ maximum clearance on sizes up to 2″, .003″ to .005″ maximum on larger sizes) plus Homestead's high-pressure lubricant system guarantee complete coverage of sealing surfaces. You are assured protection against corrosive, abrasive or erosive line fluids as well as a longer-lasting seal against leakage. Sticking is eliminated, too, by downward movement of plug during each lubrication. The net result for you is positive fluid control at very low cost per year.

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HOMESTEAD VALVE MANUFACTURING COMPANY
"Serving since 1892"
P.O. Box 160, Coraopolis, Pennsylvania

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Please send Reference Book 39-1 and prices on Homestead Lubricated Plug Valves:

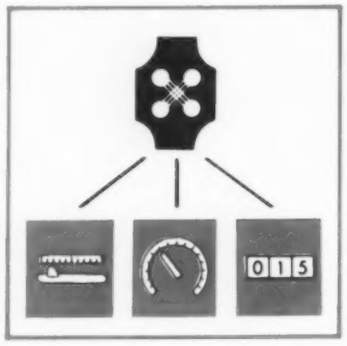
Name..... Title.....

Company.....

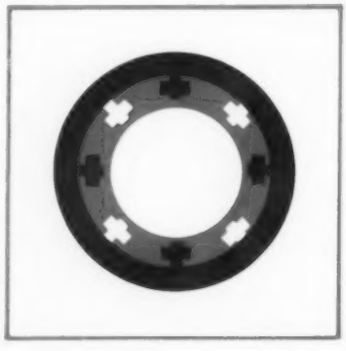
Address.....

City..... Zone..... State.....

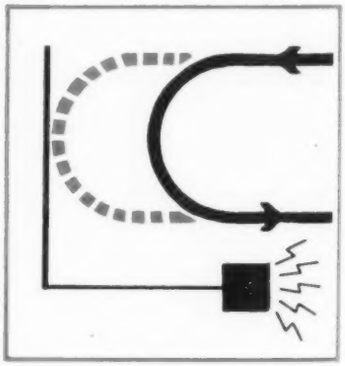
PRESSDUCTOR – for measurement of roll separating force in mills, strip tension, crane and conveyor weighing. The pressductor is a reliable load cell with high output and low impedance, specially designed for the rough environment encountered in heavy industry throughout the entire world.



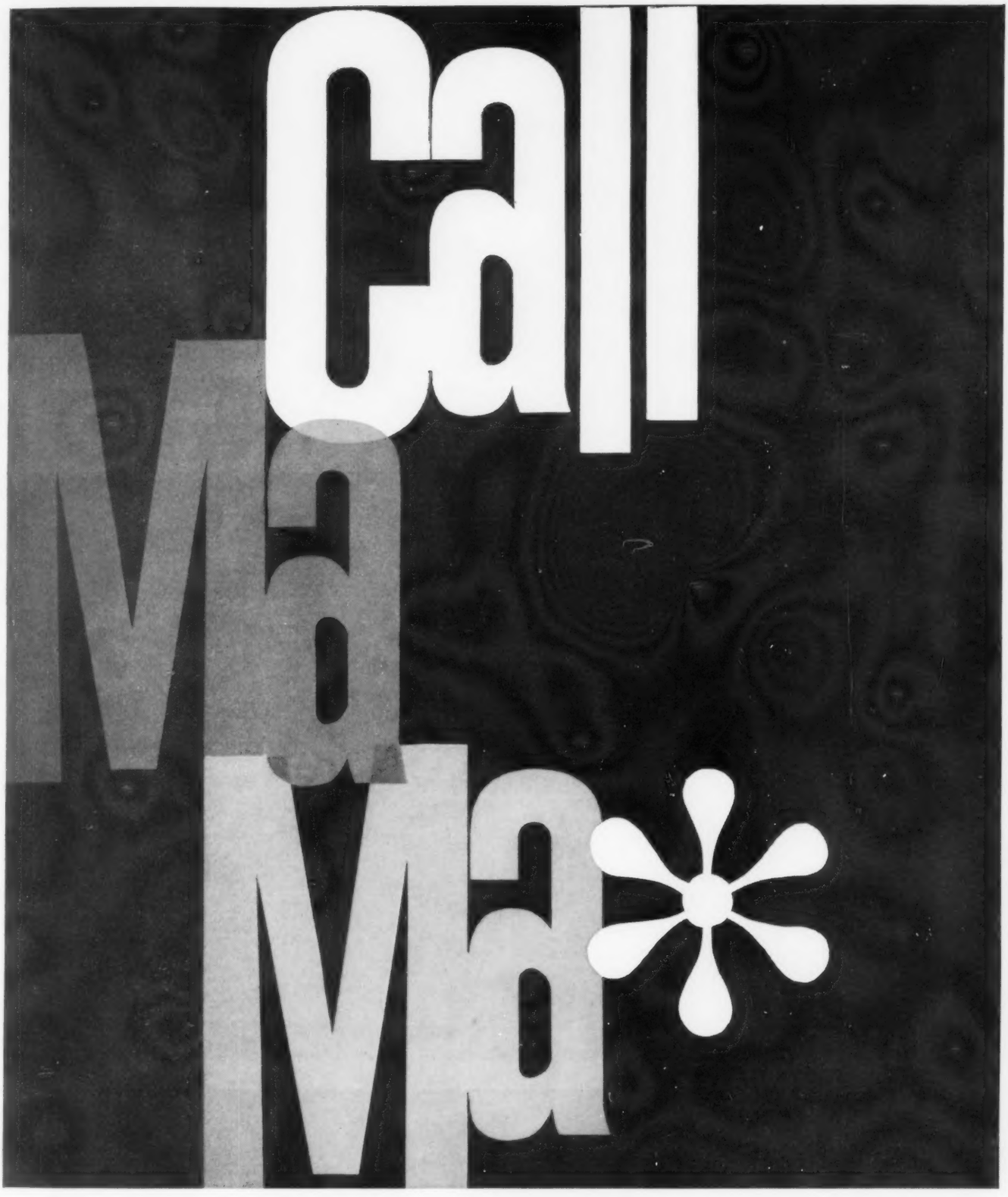
TORDUCTOR – for torque measurement. This is a very compact torque gauge, working without mechanical contact with the shaft. The torductor is accurate and reliable and is available for all shaft sizes starting from 3 in. diameter and up. Output is high enough to feed instruments and recorders directly without need of amplification.



LOOP REGULATOR – for loop regulation in hot rolling mills for wire and strip. This is a photo-electric regulator, not in physical contact with the loop. The regulator produces a DC voltage which continuously increases as the loop moves from its correct position. The movement of the source of radiation from one extremity to the other changes the output voltage from maximum positive through zero at correct position, to maximum negative polarity.

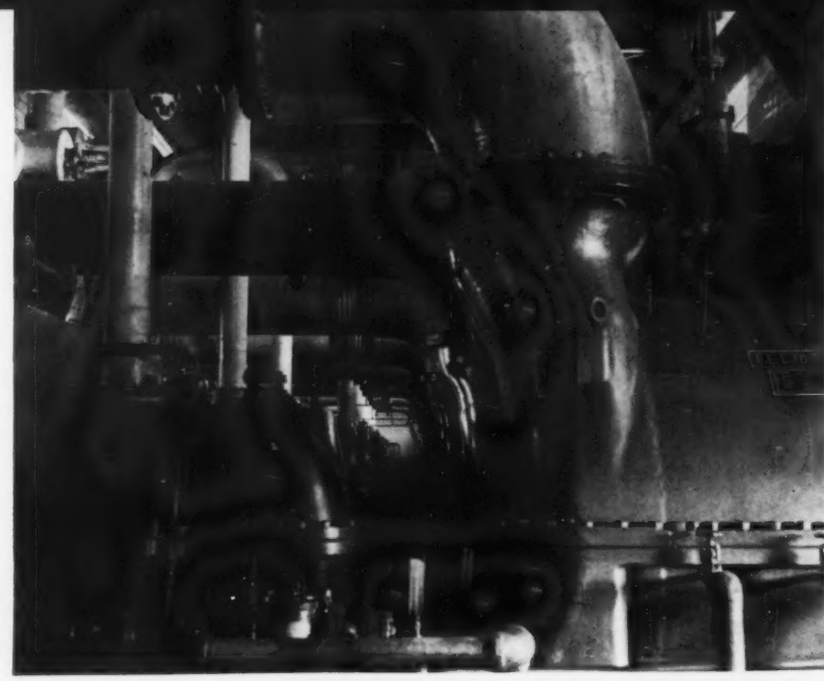


ASEA controls are widely used by industry around the world. For full information and leaflets write to: ASEA ELECTRIC INC. 500 - 5th Avenue, New York 36, New York 55 New Montgomery St. San Francisco 5, Cal. **ASEA**



*MAchinery-MAintenance Division of CORONADO STEEL COMPANY builds original, replacement and spare parts for Mill-Type equipment. MA MA is ready to help you on any parts problem. MA MA reliability and know-how saves you money and insures fast delivery. We ask only for the opportunity to bid . . . from your blueprints . . . on your next parts problem. Call MA MA . . . next time!

CORONADO STEEL COMPANY MACHINERY-MAINTENANCE DIVISION
WEST COMMERCE AND NORTH AVENUE • AREA CODE 216 • RIVERSIDE 7-4436 • YOUNGSTOWN 3, OHIO



At Weirton Steel Company, eight Elliott compressors (photo right) serve a battery of 253 coke ovens. Four are exhausters rated at 24,500 inlet cfm, and four are boosters rated at 25,000 inlet cfm. All are driven by Elliott turbines.

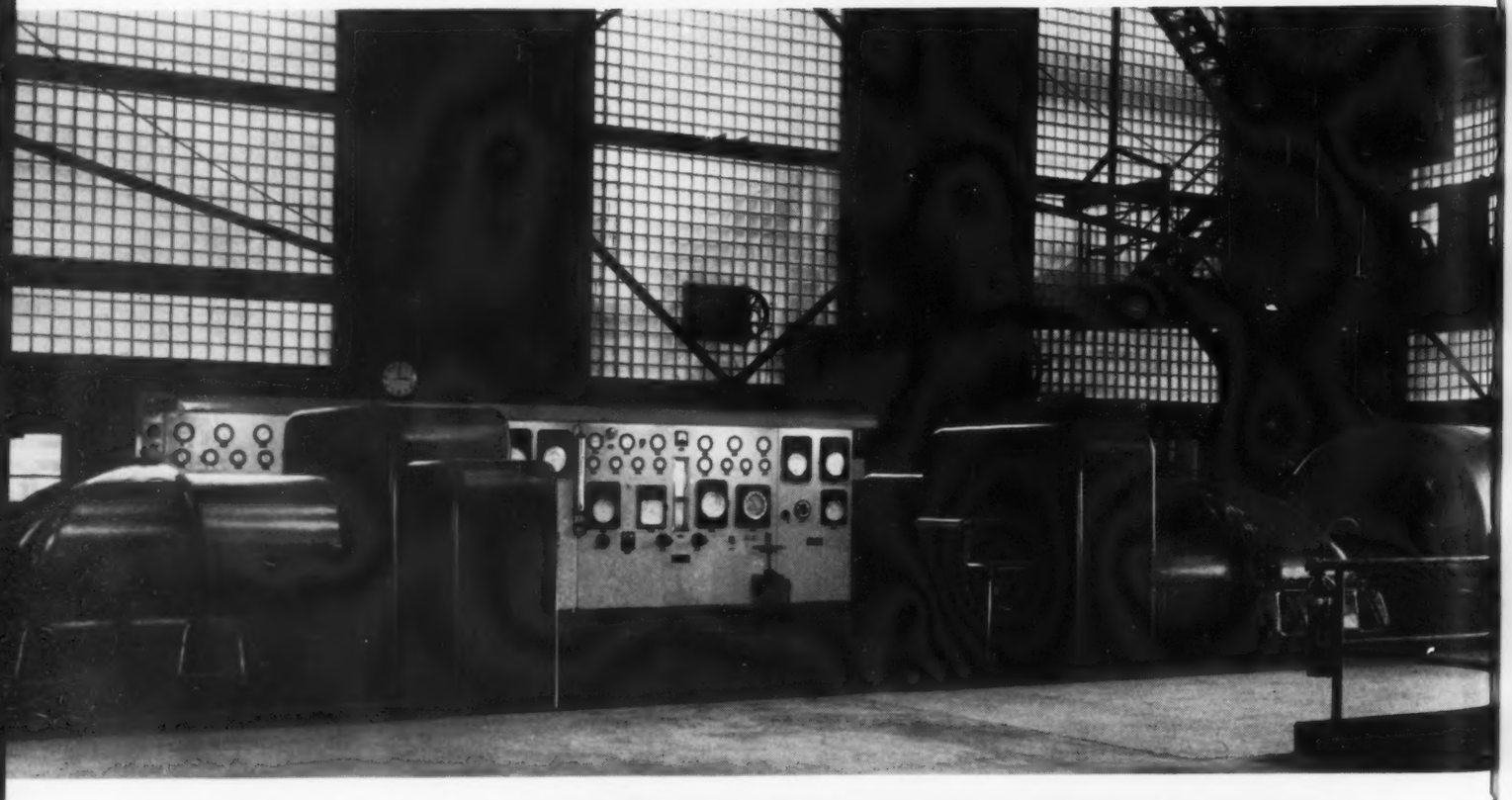


Photo above shows duplicate Elliott blast furnace compressors. Each is rated at 99,600 inlet cfm, and is driven by an 11,800-hp Elliott turbine.

At the right are shown two of three Elliott centrifugal air compressors operating in a single blast furnace plant. All three units—driven by Elliott turbines—are rated 90,000 scfm at 30 psig air discharge.

Engineered
and built
for Blast Furnace
and Coke Oven Service . . .

ELLIOTT CENTRIFUGAL AND AXIAL COMPRESSORS

Extensive experience in the design and application of centrifugal compressors is reflected in the excellent performance of Elliott machines for blast furnace and coke oven service. Since 1926, Elliott has made industrial compressors, and many of these are furnishing air for blast furnaces, and serving as boosters and exhausters for coke ovens. Typical examples are illustrated on these pages.

COORDINATED ELLIOTT DRIVERS

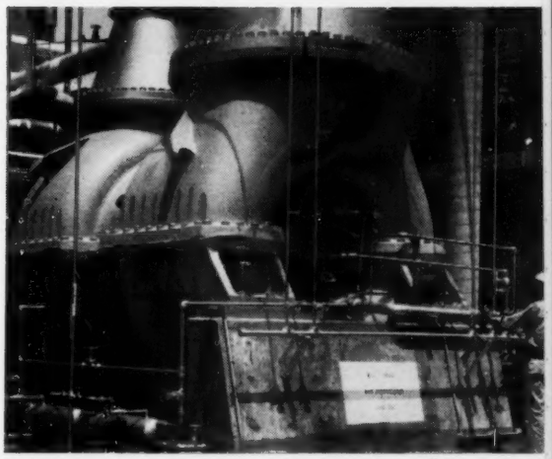
Elliott is a leading manufacturer of both steam turbines and electric motors, of all types and ratings necessary to provide driving power for compressor units. Consequently, we are in position to recommend and furnish the type of drive best suited for each application. Both units being engineered and built by Elliott is a decided "plus" because it means unified responsibility, unified service.

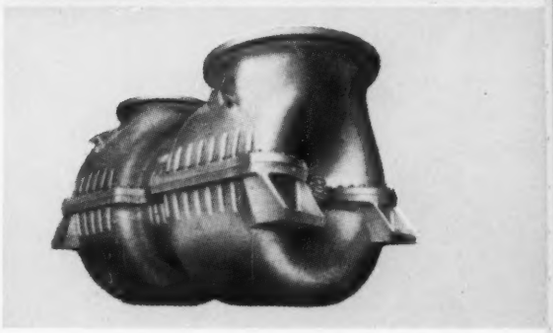
FOR AIR OR GASES

Elliott integrated compressor units are available for handling all types of compressible fluids, within the pressure and flow limits of the machines. Where corrosive gases are handled, special materials are employed in vulnerable spots; where high pressures are needed, extra heavy construction is used; where leakage must be prevented, special shaft seals are available; where high temperatures must be avoided, provision is made for cooling.

48 STANDARD FRAME SIZES

A total of 48 frame sizes permits accurate compressor application over the entire range of 500 cfm to 600,000 cfm. Pressures and speeds can be selected to meet the characteristics of the application, and the gas to be handled. For further information, write Compressor Department, Jeannette, Pa.





Multi-stage compressors of the axial flow type are designed and engineered specifically to serve the needs of the iron and steel industry for the handling of air or gas mixtures in large volume flow operation. Frame sizes are rated up to approximately 600,000 cubic feet per minute when operating on air.

ELLIOTT THE MOST COMPLETE LINE OF **INTEGRATED COMPRESSOR & DRIVER UNITS** 500 cfm to 600,000 cfm

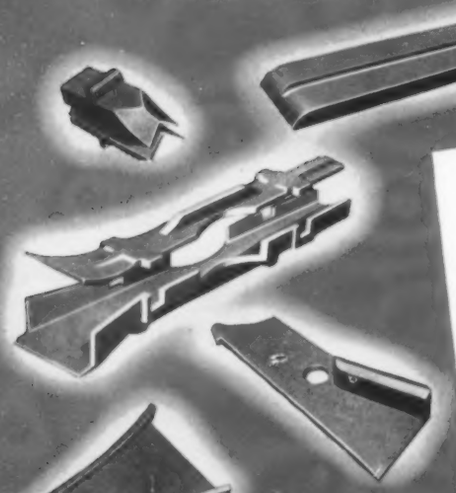
ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio; Newark, N. J.

TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS
DEAERATING HEATERS • EJECTORS • CONDENSERS • STRAINERS • TUBE CLEANERS

TRANTINYL GUIDES
THE STEEL INDUSTRY



Steel Producers amazed at HIGH TONNAGE rolled with TRANTINYL GUIDES

Entry Guides

Delivery Guides

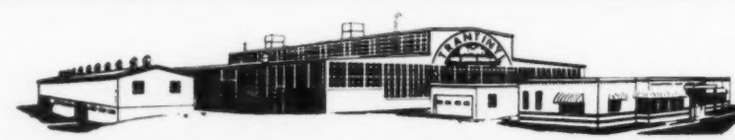
Two pair of angle guides, still in serviceable condition after long usage

These entry and delivery guides on 12" mill were photographed in a midwest steel plant after rolling unusually high tonnage. Guides showed no noticeable signs of wear and proved again the outstanding durability of "TRANTINYL." If you have not yet tested "Trantinyl" guides to your own satisfaction, why not try them now.

12" Mill showing Entry Guides

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century. Rolling more than 100,000 tons over a single pair of guides has been recorded.

Guides for Rolling Mills • Tube Mills
Straightening Machine Guides
Heat-Resisting "Trantinyl" Cast-to-Shape



Youngstown Alloy Casting Corporation
Youngstown, Ohio

G-14

Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

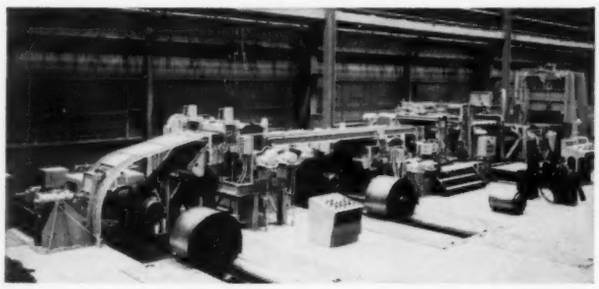
High-Speed Construction

by MURRAY

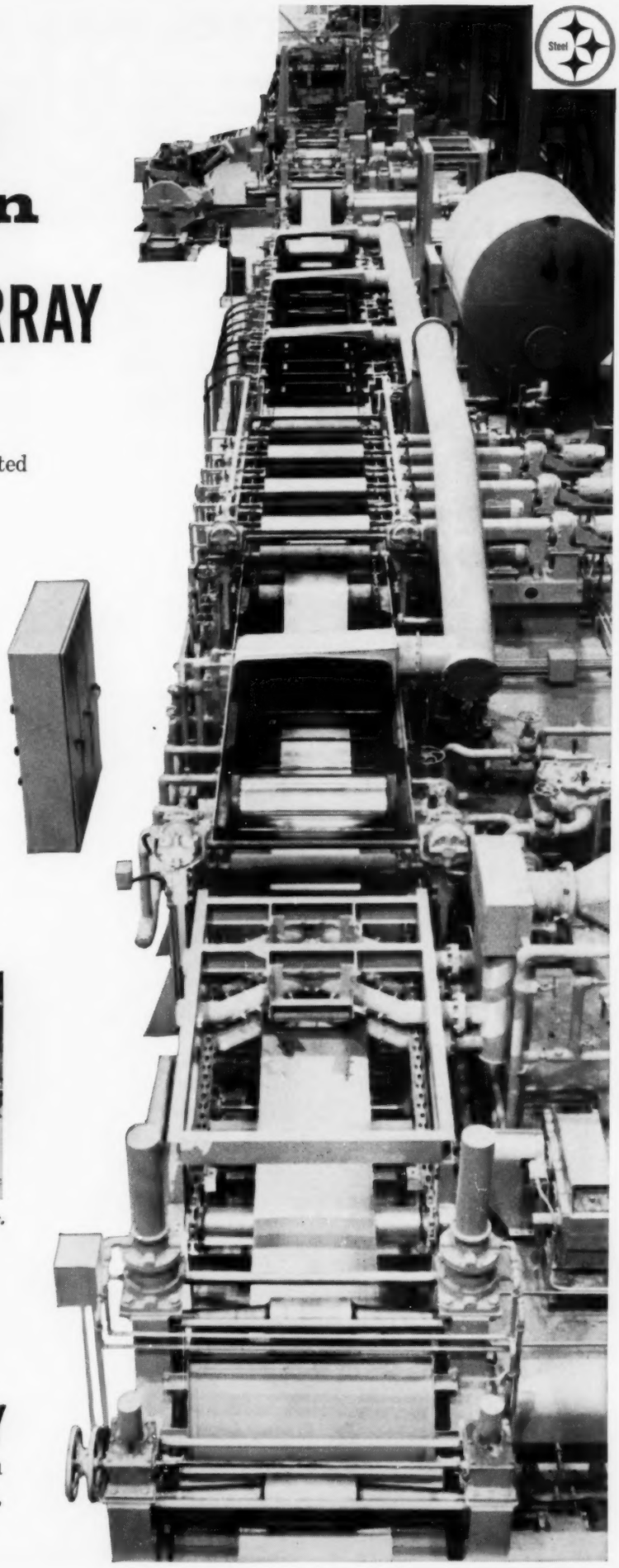
In the new flat rolled products plant of Midwest Steel Corporation, Murray has completed the installation of another Aetna-Standard high speed continuous galvanizing line, and is installing an Aetna-Standard continuous annealing line.

The galvanizing line, over 915 feet long with speeds up to 300 feet per minute, was constructed ahead of schedule in cooperation with Aetna-Standard, Division of Blaw-Knox Company, for Midwest, newest division of National Steel Corporation.

Long experience, extremely competent engineering and construction personnel are responsible for Murray's High-Speed construction method . . . an important point to remember in *your* plant expansion or modernization program.



This Aetna-Standard line receives coils up to 90,000 pounds.



Murray Makes Progress

DAVID W. MURRAY COMPANY

Detroit • Toledo • Cleveland • Pittsburgh

Main Office • P.O. Box 4768 • Cleveland, O.

PB&B STEEL MILL PRODUCTS

EBERHARDT† TUYERES

have replaceable nose of forged OFHC copper, 98% IACS; body cast of 90% IACS copper. Efficient cooling . . . water reaches nose section first, flows through machined waterways.

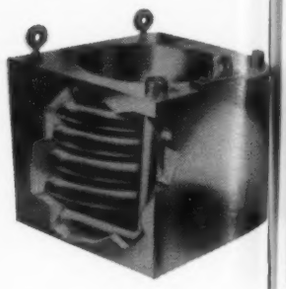
†U.S. Patent No. 2,891,783—Bethlehem Steel Company.

CINDER NOTCH MONKEYS

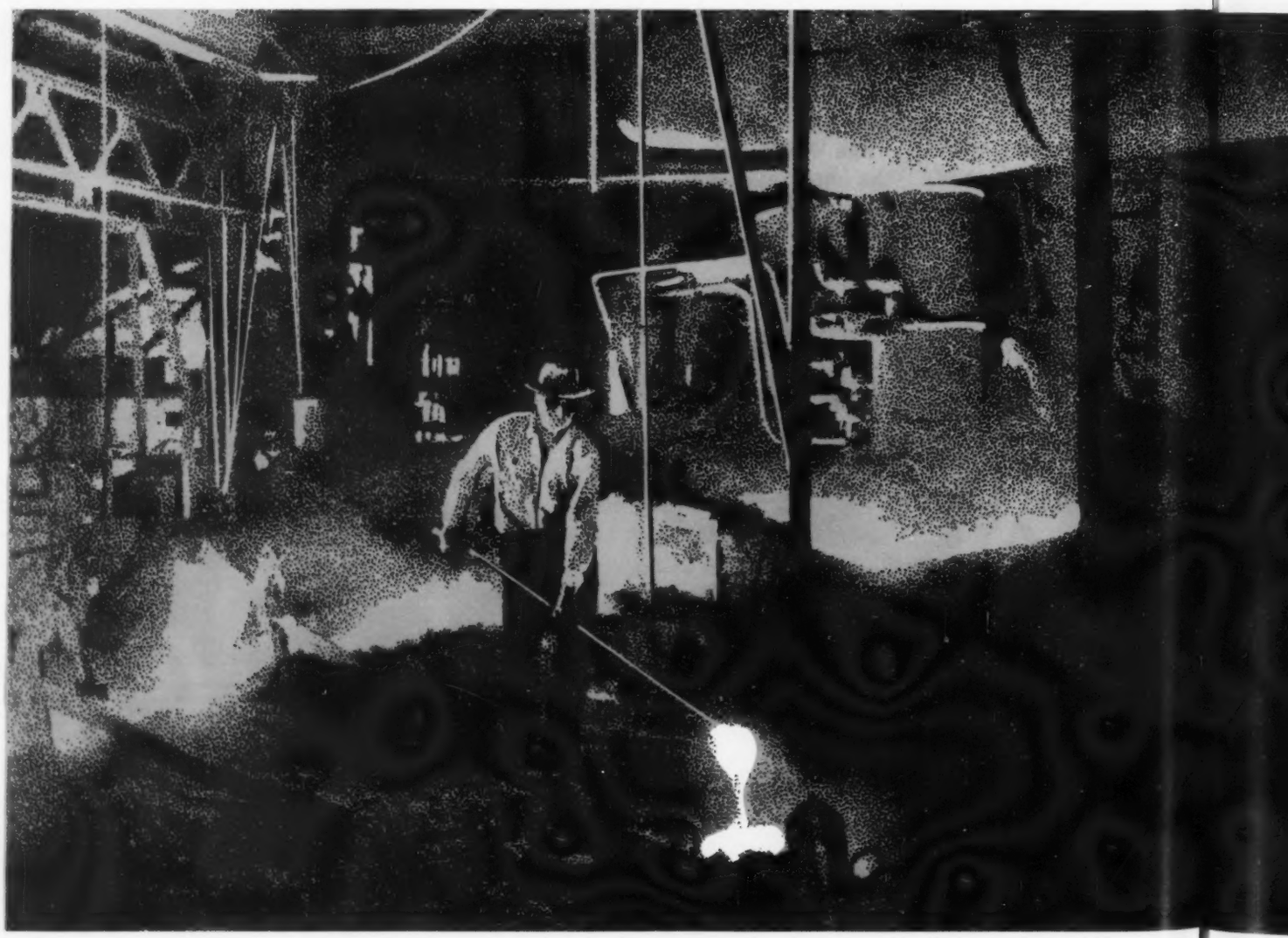
are cast of highest conductivity copper. Can be supplied with cast-in-place** copper cooling tubes also.

ROOF COOLERS

for oxygen lancing: peak cooling efficiency, for longest life, gained by cast-in-place** copper tubing in copper block.



PB&B HIGH CONDUCTIVITY

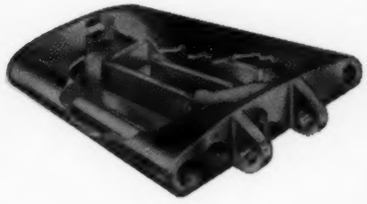


OXYGEN LANCE JET HEADS

. . . forged or cast of highest conductivity copper, to your specifications.

HOFFMAN® BOSH AND STACK PLATES

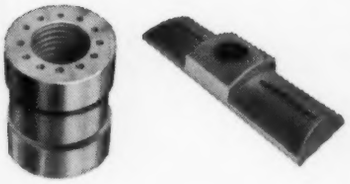
have dual cooling chambers; use cast-in-place** copper pipe for maximum heat transfer and protection against leakage.



**Patent Applied For.

SCREW-DOWN NUTS AND SLIPPERS

for rolling mills, precision-made from bronze to your requirements.



FURNACE COPPER COSTS LESS

Here's the proof. Records of tuyere life in a major steel mill show that high conductivity tuyeres last 62 to 85% longer than ordinary tuyeres. They cost 20 to 34% *less* per day of service.

Here's the reason. 88.8% of tuyere failures are due to burn-outs, in the nose, body or both. PB&B tuyeres, because they are made of highest conductivity copper run far cooler and last far longer.

Conductivity means economy. PB&B uses only the best copper to give you the peak in operating life. Our castings are made of virgin electrolytic copper, certified at least 90% IACS conductivity. Forgings are OFHC* copper, guaranteed minimum 98% IACS conductivity. And our exclusive designs and production techniques get maximum cooling efficiency from these materials.

For the maximum in service life, we supply Eberhardt tuyeres . . . which *we will guarantee* to be more economical on a day for day basis than conventional tuyeres. One piece tuyeres of highest conductivity copper also available.

We'll be glad to show you how PB&B high conductivity furnace copper products can help you cut costs. Write today for data and proposals on your specific requirements.

Furnace Products Division

PHILADELPHIA BRONZE & BRASS CORP.
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P.R. MALLORY & CO. Inc.
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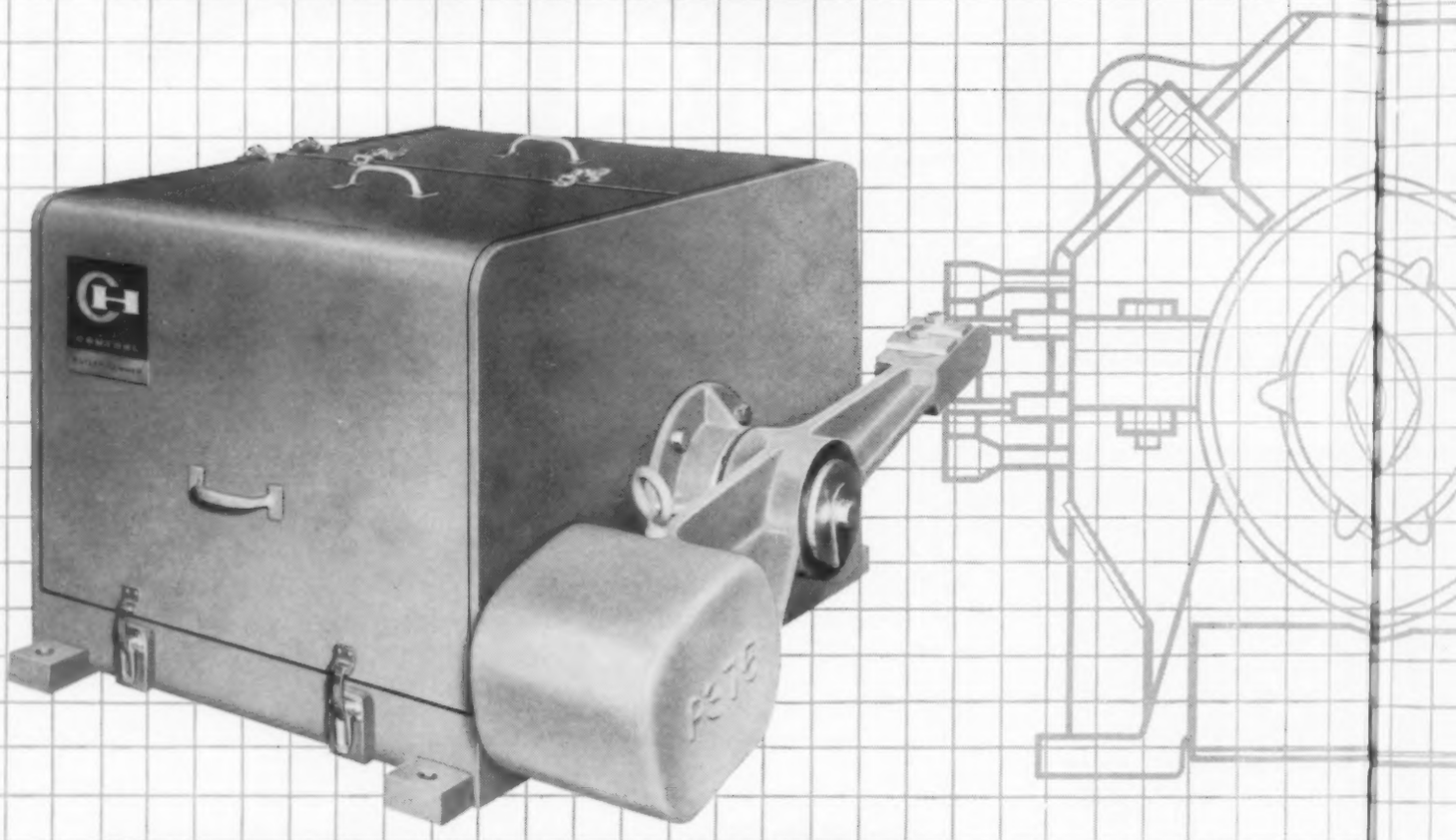
CONTROL

NEW FROM CUTLER-HAMMER!



P-375 CRANE SAFETY LIMIT STOP

EXCLUSIVE—FOR FRAME 618-622 MILL MOTORS

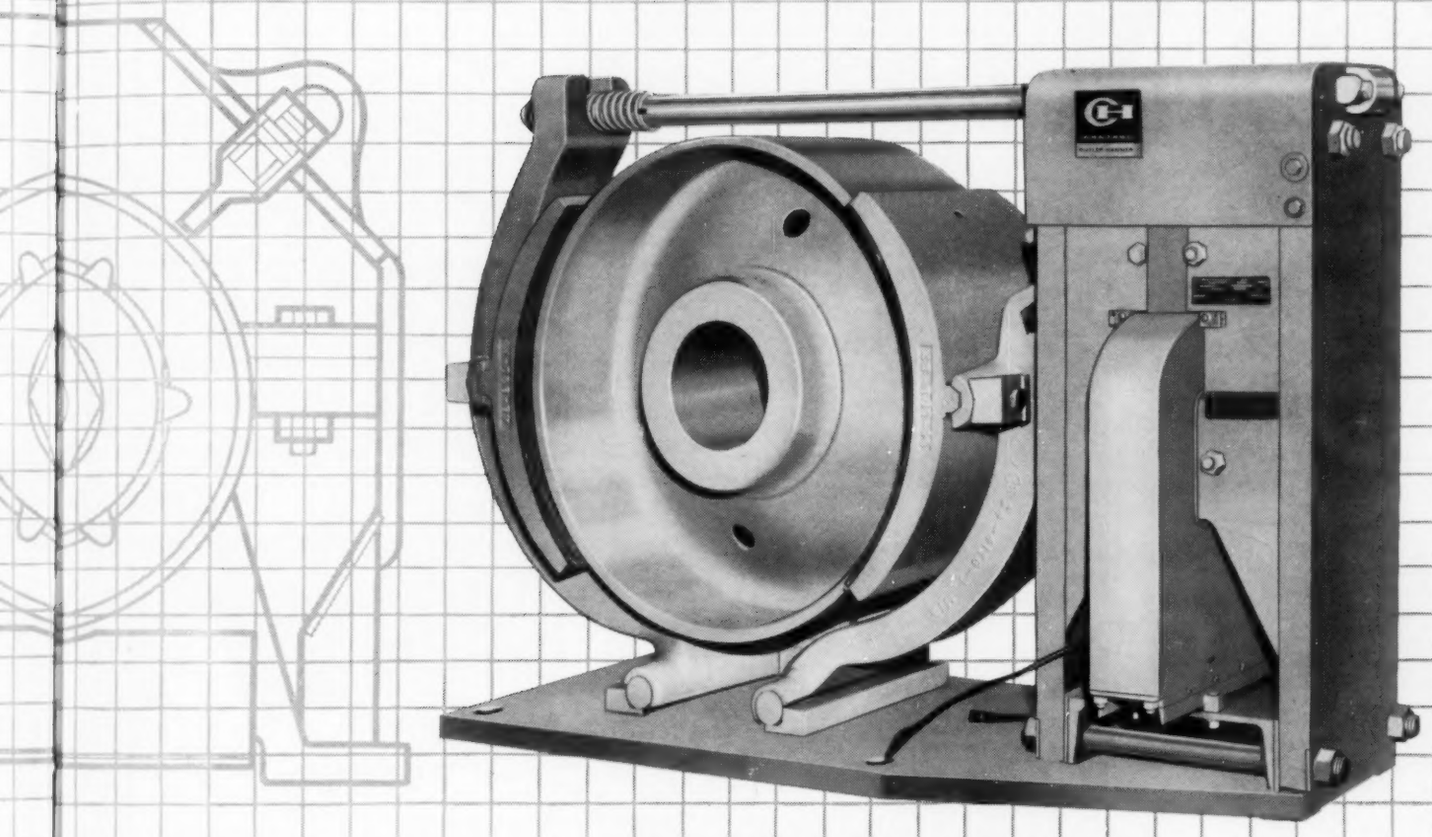
2 exclusive accessories fo

New Cutler-Hammer P-375 Crane Safety Limit Stop is especially designed for safe operation of large frame 618-622 mill motors. It is the *only* crane stop that eliminates the need for duplex switches for applications over 200 hp. Bearings are prelubricated and sealed. The heavy fabricated steel construction of the P-375 makes it highly resistant to the shock and stress of crane duty. Weathertight enclosure permits outside use. P-1, P-100, P-200 crane stops are also available for smaller cranes. For complete details call the nearest Cutler-Hammer sales office.

With the new 30″ 505 Mill Brake Cutler-Hammer offers the finest line of D-c mill brakes and the broadest range of sizes. You can get the 505 Mill Brake in 8″, 10″, 13″, 16″, 19″, 23″ and 30″.

Simplicity of design makes the 505 line extremely reliable. Only 10 major parts, all easily accessible. All adjustments can be easily made. Get full details by sending for Pub. E232.

The same kind of reliability that has made Cutler-Hammer mill control equipment preferred by so many mill engineers has been built into the P-375 Crane Stop and the 30″ Mill Brake.



30" 505 MILL BRAKE

EXCLUSIVE—FOR FRAME 620-622-624 MILL MOTORS

s for large mill motors!

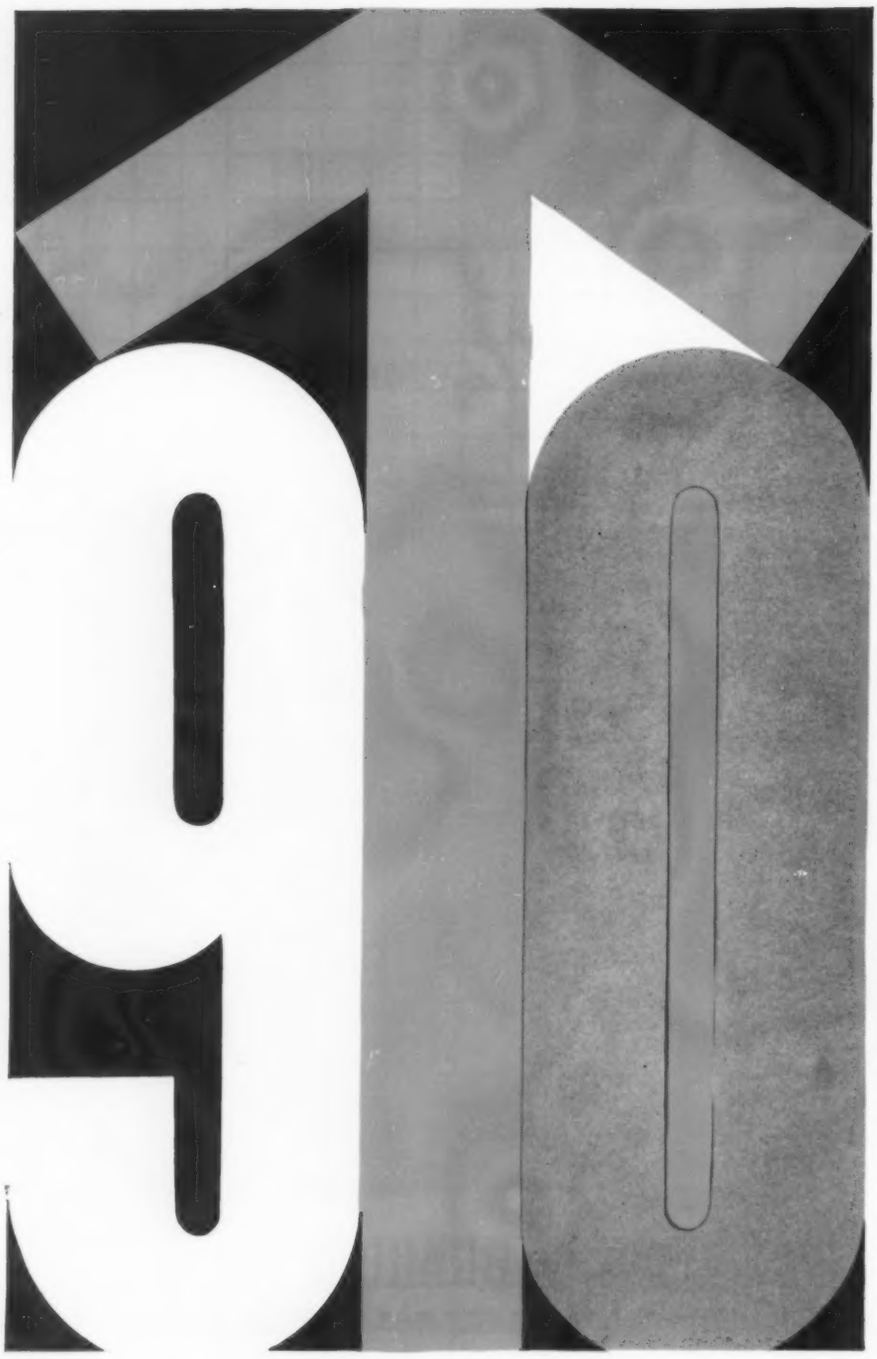
WHAT'S NEW AT CUTLER-HAMMER?
New, better products like these two are being constantly developed by Cutler-Hammer. We're ready for the great technological growth of this decade with the plant facilities, engineering talent and a desire to help you grow. Contact the nearest Cutler-Hammer sales office to see how we can help you.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A.• Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

CONTROL



New Airfoil Bladed Fans exceed 90% efficiency

It's here now—a new line of Airfoil Bladed Fans from American-Standard Industrial Division . . . all carrying the AMCA certified rating seal! A completely new design, these Airfoil Bladed Fans employ a highly efficient, quiet fan configuration ideally suited for general ventilation and industrial process applications. High mechanical efficiency, over the entire fan selection range, means the lowest possible power requirements. Get the complete story. Send for Bulletin A-1103 today. American-Standard Industrial Division, Detroit 32, Michigan. In Canada: American-Standard Products (Canada) Ltd., Toronto, Ontario.

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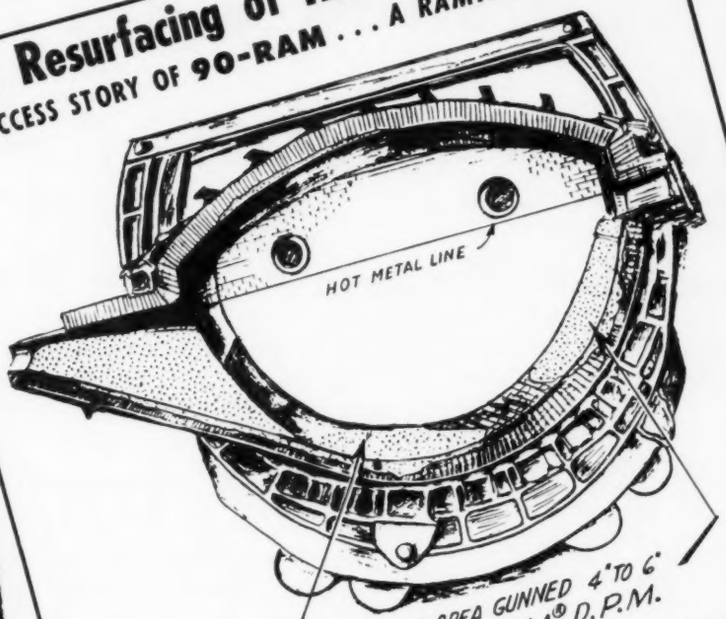
Gun Resurfacing of Hot Metal Mixer

A SUCCESS STORY OF 90-RAM . . . A RAMTITE® Product



ERODED AREA GUNNED 4" TO 6" WITH 90 RAM® D.P.M.

668,000 Tons of Hot Metal
Processed since the gunning application!

IN NOVEMBER, 1959, a 1400-ton hot metal mixer was *resurfaced* with 90-RAM DPM by refractory gun placement. From 4 to 6 inches were applied to the entire working lining, totaling 27 tons.

By June, 1960, 668,000 tons of hot metal had been processed. None of the original refractory had to be replaced and the working lining of this mixer was again relined with 22 tons of 90-RAM DPM.

Gunning saves 3 to 4 days outage time. It saves an additional 24 to 48 hours dryout time. Resurfacing possible without removing original refractory.

17 Successful Installations!

The Ramtite Co.
DIVISION OF THE S. OBERMAYER CO.

There's a RAMTITE® Product for every Refractory User!

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Please send:

☐ Further information on Resurfacing Hot Metal Mixers
☐ Representative (without obligation)

Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

Now Bethlehem forges every hardened steel roll from vacuum-degassed steel!

Bethlehem vacuum-degassed steel minimizes the hazard of roll breakage.

Pint size, king size, every in-between size. Now Bethlehem forges *every* hardened steel roll from vacuum-degassed steel.

PIONEER IN "VACUUM CASTING"

Bethlehem pioneered the development and use of vacuum-degassed ingots for highly stressed applications in the electric power, atomic energy, and other industries.

With our advanced steel-pouring techniques, we can pour molten steel from a furnace ladle to a secondary ladle within a vacuum chamber, and thereby remove harmful gases (we can also pour directly into a mold in the vacuum chamber). The secondary ladle is then taken out of the chamber and ingots of suitable size for hardened steel rolls can be cast under a blanket of inert gas.

LESS GAS MEANS SOUNDER STEEL

Because the vacuum-casting method reduces the volume of hydrogen and other gases, the steel is sounder, tougher, and cleaner than air-cast steel. It is this greater internal soundness which reduces the hazard of roll breakage.

OVER 350 ROLLS NOW IN SERVICE

In the past several years, we've produced and shipped more than 350 large, vacuum-degassed hardened steel rolls. The outstanding performance of these rolls confirms the superior soundness of vacuum-cast rolls as compared to air-cast rolls.

FAST DELIVERY . . . NO EXTRA COST

You have everything to gain (less roll breakage), nothing to lose (no price extra) by making your next purchase of hardened steel rolls Bethlehem vacuum-degassed rolls. Deliveries are excellent. Our sales offices are ready to give you the *whole* interesting story of this new Bethlehem development. Call or write the office nearest you today. Or write to us at Bethlehem, Pa.

Steel *for Strength ... Economy ... Versatility*

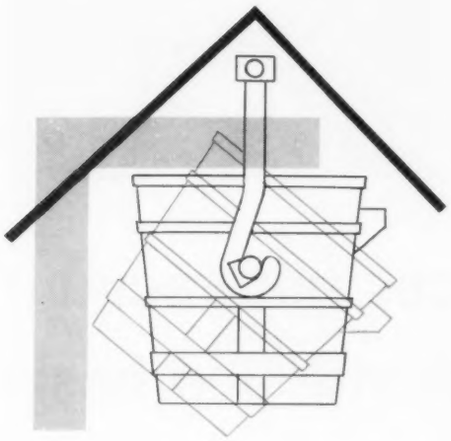
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

LOOK FOR THIS "V" STAMP on the ends of the rolls you buy . . . "V" is for vacuum. You'll find this permanent identification on every Bethlehem roll from now on . . . because from now on Bethlehem will forge *only* from vacuum-degassed steel.

LOOK FOR THIS LABEL on the packing of the hardened steel rolls you buy. It's your guarantee that your rolls are forged from Bethlehem vacuum-degassed steel . . . steel that minimizes the hazard of roll breakage in your plant.



STEEL ANGLES

THE statistics on steel imports and exports for 1960 have recently been compiled and are revealing in view of the concern that has been expressed on the subject during the past few years. The figures show a 374,000-ton balance in favor of imports. There were 3,353,000 net tons of steel products imported into the country, as against 2,979,000 exported. A breakdown of the totals by months indicates that exports were greater than imports for the last eight months of the year, but the 1,000,000-ton advantage piled up by imports during the first four months was too much to overcome. Undoubtedly, some of this margin was due to orders placed abroad during the 1959 steel strike for early delivery in 1960.

The trend of imports vs exports in the past four years has been disturbing to many steel producers as they watched very favorable balances of almost 4 or 5 to 1 in 1956 and 1957 dwindle to less than 2 to 1 in 1958. Finally, under pressure of the 116-day steel strike in 1959, the situation was reversed and imports overpowered exports by 3 to 1.

It is true that 1959 cannot be considered a normal year. Yet, in the same vein, neither can we consider 1952 a normal year, since it was interrupted by a 59-day steel strike. Nevertheless, during 1952 imports were only 1,182,000 tons as compared with 3,918,000 tons of exports—a ratio of more than 3 to 1 in favor of shipments abroad in that strike year.

In the two strike years we have utterly opposite behavior for imports and exports. The explanation for this is, of course, to be found in the growth and development of the steel industry throughout the world from 1952 to 1959. In the former year, world steel production stood at 233,000,000 tons, of which the United States produced 93,000,000, thus leaving 140,000,000 for the rest of the world. In 1959, total world production rose to 335,000,000 tons with the United States again producing 93,000,000, and the rest of the world 242,000,000. Thus the proportion contributed by the United States' steel industry fell from 40 per cent in 1952 to 28 per cent in 1959, while in absolute terms the production outside the United States increased by 102 million tons over the same span.

With this increase in output, it is evident that foreign steel producers now have the capacity to export large tonnages whenever the need and demand arises. Further, the facilities installed abroad during the past ten years are modern and capable of turning out an excellent product through an efficient and low cost operation. Thus, there is a potential threat to the United States' supremacy in the steel industry which never existed before. We have had problems with imports from time to time, but these were never too serious or of long duration because of the limited and obsolete facilities in foreign countries. This is no longer the case. We can now expect sharp competition for foreign markets and, at times, an invasion of our domestic market.

The growth in world steel output reflects a rapidly expanding demand for steel in many countries. To satisfy this, large expansions of capacity are planned. Japan, for example, hopes to produce 35,000,000 tons of steel by 1965. In 1960, it produced 23,900,000. The Common Market in Europe expects to expand its output to 96,000,000 tons by 1965, as compared with an 80,000,000-ton output in 1960. Even though this expanded production may be used outside of the United States, such as it was this year with the boom in Europe, we must be realistic and expect the Europeans and Japanese to attempt to ship a larger portion of steel here whenever their economic activity slackens. This, in fact, is happening to a small extent now. As a result of the declining boom in Europe, some steel companies contracted for deliveries in the United States during February at 15 per cent below American prices.

It is a fact of economic life that we will face this threat indefinitely in the future whenever foreign steel demand declines.

There are some in the United States who take a global view of the import-export problem and find comfort in the fact that imports represent about 4 per cent of the steel shipped by the American producers. This would not create too much of a problem if imports were actually 4 per cent of each American producer's shipments. Unfortunately for some producers, an examination reveals that the imports in 1960 were heavily concentrated in some nine categories of steel products. In each of these there were over 200,000 tons, and in two, such as pipe and concrete reinforcing bars, the figures were close to 500,000 tons, while wire products including rods accounted for almost 900,000 tons. Consequently, companies with a concentration of capacity in these products have sustained a severe blow and, at the relatively low rates of operation which prevailed during 1960, were unable to make a profit. For these few, the import situation is indeed serious and may well be critical during the coming year. ▲

Simplified controls centralize recording, indicating and monitoring of all melting parameters to ensure effective and consistent operation.

Now–LECTROMELT furnaces put vacuum melting on a low-cost production basis

Automatic operation, 20 minute loading time, sturdy design contribute to unequalled economy

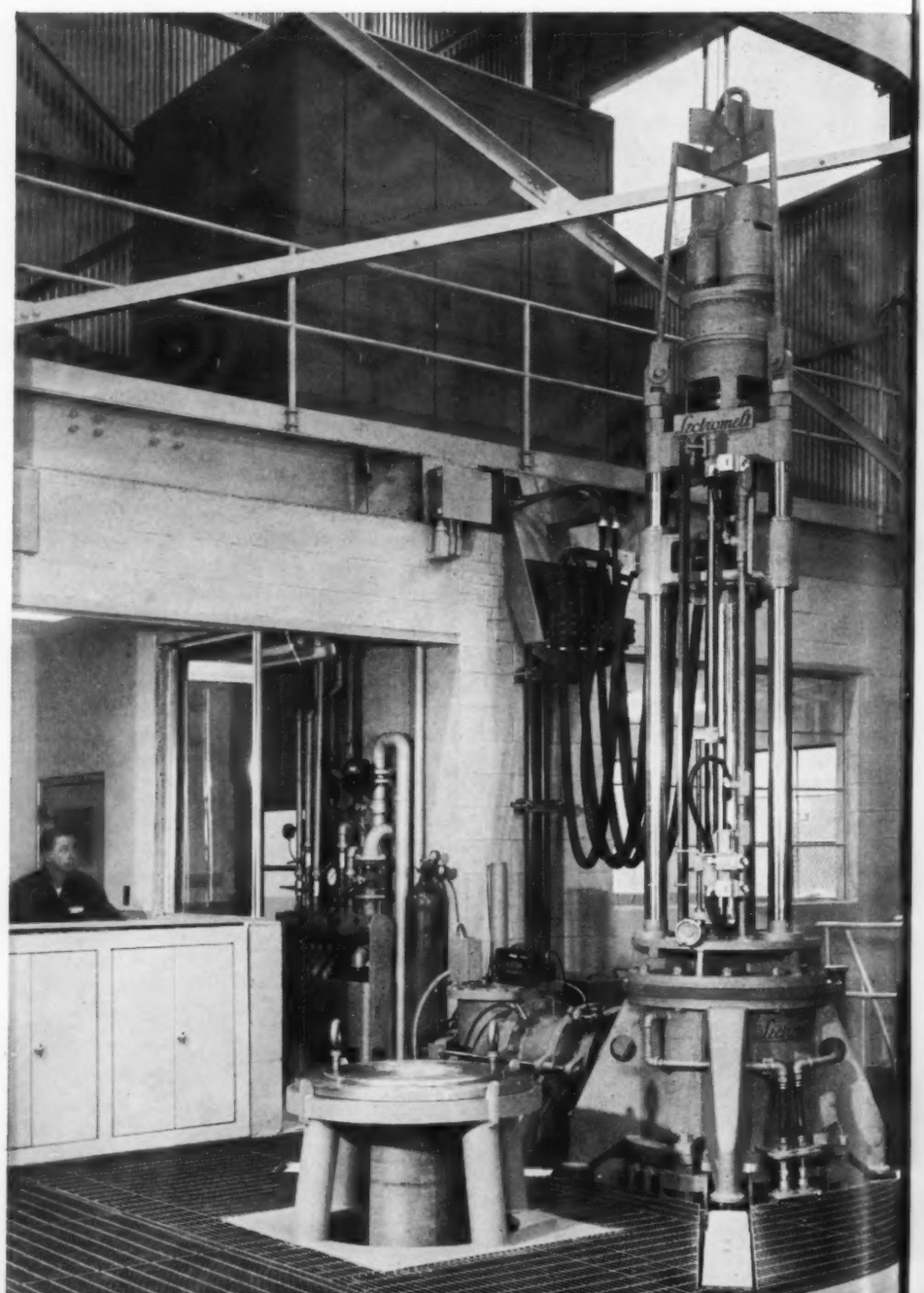
LECTROMELT vacuum arc melting furnaces are based on years of production experience in vacuum melting, plus extensive knowledge of the design, fabrication, and installation of melting furnaces for maximum production with minimum cost. Several recent installations are routinely melting a wide range of steels at a cost far below that thought of as minimum just a few years ago. Consumable electrode furnaces with melt capacities of less than 50 pounds to more than 40 tons are now available as production units.

All operating functions, including electrode and ingot handling, are performed at a single level. Three men can effectively handle two furnaces, since the highly efficient electrode control system requires minimum attention during melting, and manual operations are a minimal part of the cycle. Typical of the many advanced design features is a new electrode clamp that helps reduce turn-around time to just 20 minutes.

LECTROMELT's vacuum furnace department is staffed to handle your melting problems from concept to production. For further details please call or write: LECTROMELT Furnace Division, McGraw-Edison Company, Vacuum Furnace Department, P. O. Box 310, Pittsburgh 30, Pa., GRant 1-8782.

Lectromelt®

McGRAW EDISON



Over eight million pounds of steel have been produced by the Latrobe Steel Co. using this 20-inch furnace that melts 8500-pound ingots. The melt shop and vacuum furnace—designed and built by LECTROMELT in less than seven months—have a trouble-free record. The shop can be expanded to four furnaces.

Poised on the threshold of a tremendous expansion program—Latin America expects to make full use of its developing technological trend to achieve a balanced internal economy.

STEEL PRODUCTION In Latin American Countries

by GENERAL EDMUNDO DE MACEDO SOARES E SILVA
Director and General Manager
Companhia Siderurgica Paulista—COSIPA
Sao Paulo, Brazil
and President,
Latin American Institute for Iron and Steel
Santiago, Chile

ANY study on the steel production in Latin America must first of all consider the general characteristics of that geographical area.

Latin America extends in latitude over the larger portion of the civilized regions of the globe: it ranges from 32 degrees north to 55 degrees south latitude. Africa has about the same location on the planisphere, with Capetown corresponding to Montevideo. Almost one half of Mexico and about 1,000,000 sq miles at the south (comprising 230,000 sq miles in Brazil, 40 per cent of the Paraguayan territory, the whole of Uruguay and nearly all Chile and Argentina) are located outside the zone comprised between the tropics of Cancer and Capricorn. Through this latitude every climate except the glacial occurs.

The total area of Latin America is 7,800,000 sq miles compared with the U. S., without Alaska which is 2,980,000 sq miles and the population is 190,500,000 inhabitants distributed as follows:

	Area, sq miles	*Inhabitants*
Mexico	755,000	33,000,000
Central America	275,000	28,500,000
South America	6,750,000	129,000,000

It is at present the fastest growing population of the world at two to three per cent per year: it will go up to 275,000,000 inhabitants by 1975.

Notwithstanding natural abilities of the people, technical education has been unsatisfactory in Latin America. Only 6500 Latin American engineers graduate yearly, including every specialty and architects. About 75 per cent of these are from Argentina, Brazil and Mexico. A growing interest in mathematics, physics and natural sciences is developing and excellent up-to-date universities and laboratories are being organized in Latin America, as shown by contributions to international congresses. Current opinion, of those who are dealing with this matter, is that Latin Americans, in all the echelons of work, show an ability to learn with ease, to develop a sense of responsibility and to produce a satisfactory yield. This is clearly demonstrated by the expanding automobile industry in Brazil.

Latin America has the space, the climate and the people required to carry out any of the activities characteristic of modern civilization.

POWER RESOURCES

Hydraulic potential—Based on minimum flow, there is an availability of 80,000,000 hp and through engineering this amount may be raised at least 50 per cent. At present about ten per cent, or 8,000,000 hp, is being utilized. In comparison, the availability in Europe is 50,000,000 hp and over 35,000,000 hp is being used. North America (U. S. and Canada) is utilizing 36,000,000 hp and another 84,000,000 hp can be used. In the northern hemisphere the winter season reduces the utilization of hydraulic power during some months of the year.

It has been demonstrated that Latin American petroleum reserves are immense. During 1959 the production was 3,660,000 bbl per day against 7,050,000 bbl per day in the U. S. Oil is produced in Mexico,

Venezuela, Colombia, Peru, Argentina and Brazil. Some of these countries are self-sufficient.

According to Clarence Field Jones[1]* coal represents a negative factor in the resources south of Rio Grande; however, the facts do not entirely corroborate this statement.

In Colombia coal reserves are extremely important. They are in the three ridges of the Andes which cross the territory of the Republic. "It seems certain that the greater reserves are those of the oriental ridge, where over 6,000,000,000 tons are estimated to be spread over an area of 1200 sq miles, the major part corresponding to Cundinamarca and Boyaca." Colombians say that "there is no place without coal in the Andean section and undoubtedly a wide run of mine coal crosses the subsoil from Buenaventura on the Pacific to Goagira on the Caribe with particularly rich deposits in the Vale, Cundinamarca and Boyaca sections."[2]

Reserves amounting to as much as 1,900,000,000 tons were confirmed 160 miles northeast of Bogota. Tests have shown the existence of 20,000,000 tons of coking coal and a probable reserve of 138,000,000 tons. La Chapa mine supplies the Paz del Rio coke plant which has been working since August, 1954.

Arnulfo Villareal[3] says the following about Mexico: "Coal, in its varieties of lignite, bituminous and anthracite coal, is profusely distributed over the Mexican Republic." The most important deposits are in the Coahuila state, exploration of which began 75 years ago; these produce coking coal. The Sabinas basin alone has an estimated reserve of 2,000,000 tons. At the deepest point coal is at 1100 ft and the mines of that region are the most important of the country and feed the Monclova and Monterrey plants.

In Venezuela the availabilities of semi-agglomerating coals (Naricual) and the hydraulic reserves of the Caroni were decisive factors in the choice of the reducing furnaces of the Orinoco plant the Tysland-Hole type electrical reducing furnaces. It is possible, however, to blend coals from Venezuela with imported product (taking advantage of return freight of the iron ores exports) to produce metallurgical coke as is done in Brazil and Chile.

The coal deposits (mainly anthracite) in Peru are noted for their extent. Notwithstanding the fact that the Chimbote plant is operating an electrical reducing furnace, Tysland-Hole type, it has so far been impossible to use the Peruvian anthracite to produce pig iron; studies are being carried on in this connection.[4]

The Chilean coal deposits are well known. They occur near the coast, south of Concepcion. Lota and Coronel have been operated for many years, the mines extending under the sea. The Huachipato steel mill uses coke made by distilling a blend of the coal from those mines with imported coal from the U. S.

Argentina is at present making a great effort to utilize her coal deposits on the Turbio river. The objective is to blend part of the national production with imported coals. Operation of the General Savio plant (San Nicolas) blast furnace was started with imported coking coal.

In Brazil, there are three groups of coal reserves: in the states of Rio Grande do Sul, Santa Catarina and Parana. The coal of the deposits of the first group is not coking, estimated probable reserves: 920,000,000 tons; the deposits of the third group have some coals that agglomerate, but they have not as yet been thoroughly studied. Only the deposits of the second group (Santa Catarina) are being utilized with a view to furnishing metallurgical coal. Coal layers show up at Bom Retiro and reappear in Lauro Mueller to cross the regions of Urussanga, Treviso and Creciuma in a general north to south direction. There are several formations on the cross section of the subsoil of that region, but only that of Barro Branco (characterized for its white clay layer which divides it into two seams) is extensively mined; the Irapua layer also supplies coking coal. Probable reserves are estimated around 1,400,000,000 tons, while the proved reserves amount to 30 per cent of this figure. Deposits are mined by either open pit or deep mining; the latter usually opens on the slope and crosses the hills. Open pit mining is rather unusual and if it occurs the pits do not attain a depth of 300 ft.

MINERAL RESOURCES

An examination of the mineral resources of Latin America, essential to the implementation of the steel industry indicates very favorable conditions exist. Let us first consider the iron ores.

Mexico has excellent deposits in several areas of its territory.[6] At the present moment those of the Northern Group are the most outstanding, as they supply the Mexican steel industry of today. Located in the states of Durango, Zacatecas, Chihuahua, Coahuila and Nuevo Leon, their estimated reserves are over 100,000,000 tons; yet the abundance of ores has not justified any thorough study. The ores are hematite and magnetite, containing above 50 per cent iron. In some cases the phosphorous content is excessive and calls for blending with purer ores.

Iron ore appears in many other areas, constituting further groups of deposits: the North Pacific Group (Lower California, Sonora and Sinaloa); the Central Pacific South (Jalisco, Colima, Michoacan and Guerrero) with the most important reserves of the country and the South Pacific Group (Oaxaca and Chiapa).

The deposits of the Dominican Republic and Cuba should also be mentioned, since both countries export iron ore.

There are some considerable deposits in the Boyaca province, Colombia, at Paz del Rio, where estimated reserves reach a total of 110,000,000 tons. The Belencito plant is operated with ore from that source, with 48 per cent iron, about one per cent phosphorous and suitable for the Thomas process.

The reserves of Venezuela are well known. They are located in the state of Bolivar, south Orinoco river, and between it and the Caroni river. The deposits of Cerro Bolivar are mined by the United States Steel Corp. and those of El Pao, by the Bethlehem Steel Co. The Fairless and Sparrows Point plants are fed with these ores, hematites of 58 to 60 per cent iron presenting a good part of hard ore for the open hearth. Besides the reserves the Government of Venezuela is exporting, a much larger volume of ore is kept for national use.

In Peru, the rich deposits of Marcona, in the Nazca

* Numbers in parentheses refer to Bibliography at end of paper.

Figure 1 — Many important coal fields and iron ore deposits are located in Mexico and several integrated steel plants have been formed to take advantage of the existence of these raw materials.

province, Yca section, south of Lima and at a distance of 475 miles from the port of Chimbote, appear with an estimated reserve of more than 600,000,000 tons.[5] Exploitation is being made by the Marcona Mining Co. The product is a hematite (with some magnetite), 58 to 60 per cent iron, phosphorous below 0.06 per cent, sulphur averaging 0.1 per cent and silicon dioxide up to 6 per cent. The port of San Juan, where shipment of the ore is handled, is completely mechanized and permits a maximum flow of 2000 tons per hr. Peru exports at present almost 1,000,000 tons per year of iron ore.

Chile is traditionally an iron ore producing country, through the El Tofo deposits, with a concession to the Bethlehem Steel Co. There exist other deposits in Chile, with a total probable reserve of 2 to 3,000,000,000 tons. Ore feeding the Huachipato plant is taken by sea from the north to the south of the country, a distance of 378 sea miles. These ores are rich hematites, of a similar analysis to those of Peru.

In Argentina, an extensive iron ore deposit has been discovered in the Serra Grande Range, territory of Rio Negro, 25 miles from the coast between Antonio Oeste and Puerto Madryn, 900 sea miles from Buenos Aires and 1000 sea miles from San Nicolas. This ore resembles the Colombian ore.

In Brazil, iron ore is encountered at many places, from the Amapa and Mato Grosso (Urucum) to Rio Grande do Sul. The most important and best known deposits, however, are located in Minas Gerais, in an area bounded by lines between Belo Horizonte, Itabira, Mariana, Congonhas do Campo and Itauna.

A thorough study has been made of this region, as the result of a joint program of the Brazilian Departamento Nacional de Producao Mineral and the U. S. Geological Survey.[7] A series of memoranda are being published and the first one deals with an outline of the Quadrilatero Ferrifero. Quadrilatero Ferrifero is the name given to this area of Pre-Cambrian, because of its quadrangular shape.

This Brazilian iron ore region is linked to the Rio de Janeiro port through the broad gage railroad Central do Brazil (1.60 meter or 5 ft-3 in.) and to the Vitoria port through the narrow gage railroad Vitoria a Minas (1.0 meter or 3 ft-3 3/8 in.), there being excellent loading facilities.

Latin America is at present a major source of iron ore, and exports as much as 23,000,000 tons per year from Venezuela, the Dominican Republic, Peru, Chile and Brazil.

Other ore—Manganese ore is also a very valuable resource of the Latin American subsoil. The U. S. Bureau of Mines indicates as main producers Brazil, Argentina, Bolivia, Mexico and Chile.

The latter two countries and Brazil are exporters. From the Amapa, Brazil is exporting to the U. S. more than 400,000 tons per year, replacing sources located in other continents. The deposits in the interior of Amapa, amidst the tropical forest (Serra do Navio) are mined as open pits. The ore is then transported by a standard

gage railroad to a port at the Amazon river in a 140-mile haul. Big vessels are loaded by modern shipping techniques and head for the high seas through the northern mouth of the Amazon.

There are also enormous deposits of good manganese ore (Urucum) in the Brazilian state of Mato Grosso. The normal way to export this material is in barges down the Paraguay and Parana rivers to be shipped on big vessels from a port in Uruguay.

Nickel exists in Brazil, Chile and Cuba in reduced quantities.

Tungsten ore is produced in Argentina, Bolivia, Brazil, Chile, Mexico and Peru. Brazil is producing the metal for use as filaments in electric lamps and as tungsten carbide for the manufacture of cutting tools.

There exists titanium ore in Brazil which has been exported. Vanadium is mined in Argentina, Mexico and Peru; the latter country having exported ores and concentrates.

Molybdenum ores have been exported from Chile, Mexico and Peru.

Cobalt appears in Bolivia and Chile; Brazil has some deposits as well, mainly in Goias.

Fluorspar, dolomite, limestone, magnesite and good clays exist in many Latin American countries.

Zinc is produced in Argentina, Boliva, Mexico and Peru and soon Brazil will also become a source of zinc: two plants are under construction, one in Minas Gerias, northwest of Belo Horizonte, the other in Itacurussa, state of Rio de Janeiro.

There are tin ores in Argentina, Bolivia, Brazil, Mexico and Peru. Brazil is producing the metal, blending its own ores with imported ones.

Aluminum comes from two plants in Brazil, one in Minas Gerais (close to Ouro Preto) and the other one in Sao Paulo (in Aluminio, E. F. Mogiana). Both are now producing 12,000 ton per year and are being expanded.

The ceramic industry is spreading rapidly in Latin America and good refractories, suitable for the steel industry, are being produced: silica and magnesite bricks, silica-aluminous bricks, etc.

THE NECESSITY FOR INDUSTRIALIZATION

Taking the economy as a whole, the main characteristics can be thus stated: the Latin American countries do not have the necessary products of exchange to furnish them with the foreign credit, which is indispensable for their development. With the exception of Venezuela, who has a large surplus from its exports of petroleum, none of the other countries can develop through exports exclusively. Consequently, there is a constant crisis or exchange shortage.

Brazil is a typical example in the economy of Latin America. Predominantly a monoculture, depending on the international coffee market for the development of her internal economy, she has grave difficulties in offsetting her balance of payments. While coffee production increased, the consumer market failed to grow. The slightest alteration in terms of trade of this commodity seriously upsets Brazil's foreign exchange budget.

Practically speaking, Latin American mineral raw materials have had up to now only one big market, the U. S. The swing in prices is frequent and violent, causing great disturbance among the exporters. These economic difficulties are reflected by the internal policies of the countries in crisis and there result great losses in general prosperity and unbalance in international trade. For this reason it seems that all the potential difficulties in Latin America can be solved through sound investments, both at the private and governmental level. Political disturbances in Latin America or anywhere else are generally a result of economic unbalance and not a cause.

Industrialization in Latin America is a consequence of the situation outlined above. It is the only way to improve the living standard of the growing population, since normal exchange of commodities is no longer sufficient.

THE STEEL MARKET

Before the second world war steel consumption in Latin America was extremely small totaling 3,256,000 tons of rolled products (or 4,930,000 tons of ingots) for the 20 republics, 52 lb per capita. Two thirds of this quantity was consumed by four countries: Argentina, Brazil, Mexico and Venezuela.

Latin America absorbed about 9,000,000 tons of ingots, or 96 lb per capita, in 1959, production and consumption being estimated as follows:

Countries	*Production tons x 1000*	*Consumption tons x 1000*
Mexico	1350	1750
Central America and Caribe	30	980
Venezuela	100	1050
Colombia	120	250
Ecuador	...	85
Peru	53	110
Chile	460	440
Argentina	350	2000
Uruguay	25	45
Bolivia	...	55
Paraguay	...	55
Brazil	2100	2500
Total	4608	9320

Steel imports amounted to 3,100,000 tons of rolled products, equivalent to 4,700,000 tons of steel ingots, at an approximate value of $480,000,000.

STEEL PRODUCTION

The enormous deficit in steel production and the continuous increase of the consumption showed Latin America that the only solution would be to expand her steel producing facilities.

Prior to World War II steel production in Latin America amounted to about 800,000 tons per year. In a period of 20 years (from 1940 to 1960) production increased 5.3 times, which meant an extraordinary effort.

MEXICO

Mexico was the pioneer. During the war the steel problem was faced and the first integrated steel plant

was erected south of the Rio Grande river, while old plants were expanded and new ones built to diversify production.

The oldest enterprise with 100 per cent private capital is Cia. Fundidora de Fierro y Acero de Monterrey S. A. Its present capacity is 500,000 tons of steel ingots. Originally it rolled only bars and structurals; however, a branch office was formed recently. Cia. Fundidora de Fierro y Acero de Monterrey, which installed a 66-in. semi-continuous rolling mill, producing at present 280,000 tons of plates and strips, while future production is scheduled to reach 550,000 tons. Cia. Fundidora is an integrated steel mill, going from blast furnaces to the finished products.

Altos Hornos de Mexico S. A. is another integrated steel plant for flat products. In 1957 its capacity was 415,000 tons of ingots and through its current expansion, production will increase to 660,000 tons in 1962. The plant is located in Monclova.

Hojalata y Lamina also produces flat products, cold rolled plates and tin plate. This enterprise is noted for its production of "sponge iron," obtained from direct iron ore reduction through the passage of a current of desulphurized natural gas mixed with steam, with a catalyst; hydrogen and carbon monoxide are obtained and go through a quench tower to cool off; the latter mixture is led to a reactor containing iron ore and a sponge is obtained where the ratio of metallic iron to total iron is 85 per cent.

Due to insufficient coke supply and transportation difficulties, the Mexican steel industry has been unable, for some time, to produce at its full capacity. Scrap has been imported from the U. S. on a large scale: 290,000 tons in 1957. This situation improved after the erection of a new coke plant in Monclova and with the local production of sponge iron.[8]

As already said there are coal and iron deposits in other parts of the country and this points toward the necessity of developing new sources of steel production in the near future.

VENEZUELA

Venezuela has planned an entirely new mill, alongside the Orinoco river, west of Puerto Ordaz at the locality called Matanzas, which takes advantage of the gigantic work performed by U. S. Steel to export iron ore from Cerro Bolivar: the construction of a railroad between the deposits and port of shipment and the drainage of a river to permit access of deep draft vessels. The selection of the steel mill site was made so as to receive:

1. Ore transported by U. S. Steel.
2. Coal or coke by return of vessels that transport iron ore.
3. Electric power from the Caroni river.
4. Access by river and sea for the flow of production.

It is an integrated steel mill and has the following main characteristics:

1. Initial production of 650,000 tons of steel ingots, with a possible expansion to 1,500,000 tons.
2. Pig-iron production in nine electric 25,000-kva reducing furnaces Tysland-Hole type.
3. Steel shop with four 150-ton open hearth furnaces.
4. A 42-in. blooming and slabbing mill.
5. Bar and structural mills.
6. A wire mill and equipment to produce barbed wire.
7. A seamless pipe mill to produce 100,000 tons of finished products.
8. A foundry to make centrifugally cast iron pipes.

The Venezuelan mill belongs entirely to the Government and is being erected by an Italian firm. Equipment has been purchased in the U. S., Italy and Norway. Operation was scheduled to start in late 1960, having been delayed due to the erection of the Caroni river hydroelectric power plant.

COLOMBIA

Until 1954 Colombia had only one small private steel enterprise in Medellin, producing reinforcing concrete bars and some simple small structures up to 1½ in. Since then a new integrated plant has been built in Paz del Rio, Boyaca state, at an altitude of 8000 ft, for the production of 150,000 tons of steel ingots per year. The equipment was built and financed by French industries and banks, and the concern is owned by the State.

The steel mill consists of a coke plant, a blast furnace rated at 550 tons per day, a steel shop with two Thomas converters and a 30-ton 3-phase melting and refining electric furnace and rolling mills for bars and structurals. The installation of the rolling mills provides for hot rolled plates. A wire mill completes the equipment.

As a whole the plant is well balanced and if Paz del Rio still presents operational problems it is due to difficulties connected with the use of raw materials, training of personnel and minor adjustments of the material to its purposes.

PERU

In Peru, Planta Siderurgica de Chimbote has been erected north of Lima. It is associated with Central Hidroeletrica de Canon del Pato and was inaugurated in April, 1958. The concern is managed and operated by SOGESA (Sociedad de Gestion de La Planta Siderurgica de Chimbote y de la Central Hidroeletrica del Canon del Pato S. A.): 75 per cent of the stock belongs to Corporacion Peruana del Santa and the remainder to a French group.[9]

The mill has two 15,000-kva reducing furnaces. Coke is imported and local anthracite has not yet been used. In 1959 production was 43,000 tons of pig iron.

Steel is made in a 3-phase electric furnace, using pig iron, scrap and hot metal: 58,000 tons of steel ingots were produced in 1959.

The rolling mill comprises a 3-high blooming mill; a barmill for reinforcing concrete bars ⅜ and 1 in., and ⅜ to ¼-in. wire rod, in reels and equipment to produce hot rolled plates consisting of a rougher and a finishing unit, both 3-high. The plate equipment is completed by a galvanizing line. Total capacity of the rolling mill is 140,000 tons per year.

Figure 2—Since the beginning of the second world war steel consumption in Latin America has risen over 200 per cent furnishing the impulse which has forced many countries to expand their steel producing facilities.

CHILE

In Chile, the great step toward development of steel production on a modern basis was the erection of the Cia. de Acero del Pacifico plant, in Huachipato, six miles west of Concepcion, on the Pacific coast.

The purchase of equipment in the U. S. has been financed by the Export-Import Bank of Washington, D. C. Huachipato is an important achievement of the Chilean Government.

The installations comprise:

1. Coke plant and by-products plant.
2. Blast furnace rated at 800 tons per day.
3. Open hearth steel shop.
4. Rougher and bar mills.
5. Flat products mills, comprising a 3-high Lauth mill as a plate rougher and a 4-high Steckel as a hot strip mill.
6. A 3-stand 4-high tandem cold mill.
7. A tin-plate hot-dipped installation.
8. A galvanizing line.
9. Old hand mills still in operation.

Attention should be called to the fact that the plant suffered only minor damage during the earthquake that devastated the southern part of the country. The plant design had taken this possibility into account and the results have been remarkable.

The solution given to the production of hot rolled strip will restrict the capacity of the plant, but it was a simple and cheap one, taking benefit of an existing major piece of equipment such as the 3-high mill rougher (Lauth type mill), but Chile is planning to expand Huachipato to double the present production.

Chile exports about 25 per cent of its production, mainly to Argentina and Brazil.

ARGENTINA

Argentina, in spite of representing one of the most important markets for steel in Latin America, has delayed the establishment of a great steel mill on its territory. The lack of adequate raw materials, agricultural tradition and local cattle-raising, beside several other political and economic factors, have for a long time postponed the solution of this problem. However, the situation has changed.

In Zapla a steel mill has been erected based on the charcoal and iron ore of that region. Its production has reached 120,000 tons of steel ingots per year and with the current expansion it is expected to produce 350,000 tons: special steels will be produced and rolled in this mill.

The decisive step, however, toward steel production was made at the start of the erection of San Nicolas plant (the General Savio plant), alongside the Parana river, with a port for the docking of 10 to 14,000-ton vessels for the handling of raw materials and dispatch of finished product.

San Nicolas is a great integrated steel mill and comprises:

1. Coke and by-products plant.
2. A 28-ft hearth blast furnace.
3. Steel shop with four open hearth furnaces of 250 tons each.
4. A 44-in. blooming, slabbing mill.
5. Continuous hot strip mill 66-in. wide.
6. A 66-in. cold tandem mill.
7. Galvanizing line.
8. Continuous bar mill.
9. Rail and structural mill.

The General Savio plant at San Nicolas is located 125 miles northwest of Buenos Aires and 50 miles from Rosario, in the Buenos Aires province.

The coke plant and the blast furnace were inaugurated in July, 1960, and the steel mill is scheduled for operation in March, 1961. The other plants of the steel mill will be put successively in operation. Initial foreseen production is 700,000 tons of steel ingots.

The enterprise is managed by a corporation in which the Government is holding the major part of stock: Sociedad Mixta Siderurgia Argentina (SOMISA). Operation was started with iron ore from Brazil, Chile and Peru and with coal imported from the U. S. Gradually national coal and ores will be used in blends with the imported product.

There exists another project in Argentina for the erection of a new steel plant. It is the Altos Hornos de Parana project in Rosario, alongside the Parana river. Initial capacity would be 500,000 tons of ingots per year.

BRAZIL

Brazil has produced iron since 1812. However, the iron production was only developed after the first world war, following innumerable and unsuccessful earlier attempts. Small rolling shops were established in the states of Minas Gerais, Rio de Janeiro and Sao Paulo. In Minas Gerais, new charcoal furnaces were erected and in 1928 Cia. Siderurgica Belgo-Mineira was organized through the purchase of a Brazilian company that had a small setup in Sabara (two charcoal blast furnaces, an open hearth steel shop and rolling mills for production of concrete reinforcing bars).

Cia. Siderurgica Belgo-Mineira improved and expanded the Sabara facilities, bought new properties and, in 1937, inaugurated an integrated steel mill in Monlevade, to produce bars and small and medium-sized structurals. During the war, rails up to 85 lbs per yard were produced in Monlevade. It is at present the world's greatest charcoal mill and owns an extensive area with natural and artificial forests, several kinds of eucalyptus being used for reforestation: artificial forests become exploitable in eight to ten years' time, an extremely rapid cycle that can only occur under the special conditions of the Rio Doce valley. Monlevade soil contains rich iron ore. The plant produced in 1959 some 385,000 tons of steel ingots and is being expanded to reach a yearly production of 550,000 tons within two years. Equipment of the mill comprises:

1. Four blast furnaces, operating with a high sinter load; one of these blast furnaces has just produced an average of 375 tons per day of pig iron during six days, a record for charcoal furnaces.
2. Steel shop with four open hearth furnaces of 70 tons each and two 20-ton L-D converters.
3. A 35-in. 2-high reversible blooming, slabbing mill.

4. Bar mill.
5. Wire mills.
6. A 25-in. Steckel mill.
7. Tube mill (electric welded).
8. Galvanizing line and auxiliaries.

After thoroughly studying the problem, the Brazilian government began in 1939 to prepare for the erection of a great integrated steel mill in the country, with a view to produce flat products, heavy rails and structures. Shortly thereafter the war began in Europe, but the Brazilian government carried on with its plans. From 1940 to 1946 the Volta Redonda (Rio de Janeiro state) steel mill was erected with governmental and private capital, owned by Cia. Siderurgica Nacional. The plant facilities are alongside the great Paraiba river. The Central do Brasil railroad (broad gage) and Rede Mineira de Viaçao railroad (narrow gage) serve the mill which is also linked to the excellent Rio-Sao Paulo highway.

If a circle with a 260-mile radius is drawn having Volta Redonda as the center, we find 80 per cent of the steel consumers of Brazil concentrated in that area. Iron ore, manganese, dolomite, limestone, electric power, the best means of communication and transportation of the country and an adequate manpower supply are also included.

Pig iron flowed for the first time in June, 1946. In 1947 the initial production of rolled products was sold; thereafter, the plant expanded continuously, it being now constituted as follows:

1. Coke batteries with 120 ovens and by-products plant.
2. Two blast furnaces (one 26-ft hearth, and one 26 ft-6-in.)
3. A sintering plant for 2600 tons per day.
4. Steel shop with eight 220-ton open hearths with oxygen injection through the roof.
5. A 40-in. blooming, slabbing mill, 2-high reversing.
6. Complete equipment with two 29-in. 3-high and a 23-in. 2-high mills to roll bars, structurals and rails up to 150 lb per yard.
7. A 72-in. reversing 4-high plate mill and a 72-in. nonreversing 4-high plate mill.
8. Continuous 6-stand, 50-in. 4-high hot strip mill, with an x-ray gage thickness measuring device.
9. Two down-coilers.
10. Two continuous pickle lines.
11. Cold tandem mill, 4-stand 50-in., 4-high and a cold tandem mill, 3-stand 52-in. 4-high.
12. Galvanizing line.
13. Hot-dipped tin-plate shop with six machines.
14. Continuous electrolytic tinning line.
15. Two electrolytic pickle lines.
16. Temper mill and a skin pass mill (two 4-high stands in tandem), and all auxiliaries for heating, heat treating, shearing, butt-welding, etc.

Volta Redonda produced in 1959 some 962,000 tons of steel ingots and in 1960 was to produce 1,300,000 tons, corresponding to 960,000 tons of rolled products. Cia. Siderurgica Nacional became the leading steel producer in Latin America. Its success opened the door to other ventures in several countries, and it is now a training center for Latin American technicians (Colombian, Venezuelan, Argentine) and even trainees from Burma who have stayed at the plant: on behalf of the United Nations World Technical Assistance Plan.

Other integrated plants producing bars, structurals and wire, worthy of mention, are Mineracao Geral do Brasil (Sao Paulo), Siderurgica Barra Mansa (state of Rio de Janeiro) and Aliperti (Sao Paulo), all with charcoal blast furnaces and open hearth and or electric melting furnaces.

Some small plants producing steel ingots out of scrap, or rolling only purchased billets, exist all over the country. Worth mentioning is Cia. Siderurgica Rio Grandense, in Porto Alegre (Rio Grande do Sul).

Industrial development of Brazil brought about the production of alloy steels. Some of the leading plants are worth mentioning.

Cia. de Acos Especiais Itabira at Acesita, Cel. Fabriciano, Minas Gerais, in the Rio Doce valley. Its equipment consists of:

1. Charcoal blast furnace, 150 tons per day and a 17,500-kva electric Tysland-Hole type reducing furnace rated at 145 tons per day.
2. Sintering plant rated at 600 tons per day.
3. Steel shop comprising one 10-ton Bessemer converter and three electric melting furnaces, of 33-, 30- and 7-ton capacity.
4. A 34-in. blooming, slabbing mill.
5. A 26-in. 3-stand, 2-high reversing bar mill.
6. Intermediate bar mill, comprising four 3-high stands in line, one of 24-in. and three of 18-in.
7. Finishing bar mill, comprising five 3-high and one 2-high stands in line, 16 to 12-in.
8. All auxiliaries, including reheating and heat-treating furnaces, shears and saws, cooling bed, straightening machines, etc.

This enterprise owns a large tract of land and employs charcoal from natural and artificial forests; it belongs to Banco do Brasil and to private investors; its large and excellent iron ore mines are in the Itabira region. The plant is 300 miles from the port of Vitoria (Espirito Santo state) and 150 miles from Belo Horizonte (Minas Gerais); a narrow gage, 40-in. railroad (the Vitoria-Minas) goes from Itabira to Vitoria. A modern highway is being built between Belo Horizonte and Vitoria, crossing Acesita.

Cia. Siderurgica Mannesmann at Cidade Industrial, Belo Horizonte (Minas Gerais state), is a private enterprise owned by a German group and Brazilian stockholders. The present production program comprises seamless tubes and alloy steels, mainly for the automotive industry. Its equipment is as follows:

1. Two 17,500-kva reducing furnaces Tysland-Hole type employing ore from a nearby mine and imported coke, besides a certain amount of coke breeze from Volta Redonda.
2. Steel shop with two 15-ton acid converters and two 30-ton electric furnaces, basic lined.
3. A 28-in. 3-high as a rougher, with two stands in line.

4. Tube mill for 1¾ to 12-in. O.D. seamless tubes.
5. Bar mill with six stands in line.

A plan to expand the plant has been approved. A normal blast furnace and more steel facilities, oxygen in the converters and new rolling mills will be added. Production will reach 385,000 tons of steel ingots.

Aços Vilares S. A. produces only special steels, rolls for rolling mills (steel and chilled iron) and steel castings for machinery. It is a private enterprise.

Its steel mill has two electric furnaces, the largest one has a 35-ton capacity. Bar mills with a 3-high rougher constitute the rolling shop. All the auxiliaries for producing quality steels exist in this plant. One 2000-ton hydraulic press and several hammers are in the best forging shop of the country. Aços Vilares' total production is 35,000 tons per year of steel ingots and castings.

It would be difficult, if not impossible, to describe even shortly all the other existing plants, some of which are to expand and become big private enterprises. However, reference must be made to three important projects now under construction, which will most definitely increase the steel production of Brazil.

The first one is Cia. Siderurgica Paulista (COSIPA) whose headquarters are in Sao Paulo, the plant being erected at present in Piacaguera (Cubatao, state of Sao Paulo), 25 miles from Santos, at tide water level. This enterprise is to be a private one, in spite of having both the Federal and the state of Sao Paulo Governments as stockholders.

All the equipment has already been purchased. The specifications call for equipment of the American type, but due to the necessity of obtaining credits, only part of it has been bought in the U. S. Part of the equipment is:

1. Coke ovens and by-products plant.
2. Blast furnace, 28-ft hearth.
3. L-D oxygen converter plant with two 66-ton vessels.
4. Soaking pits.
5. A 44-in. slabbing mill.
6. A 110-in. 4-high reversing plate mill.
7. A 5-stand 66-in. hot strip mill with one downcoiler.
8. A 3-stand 4-high 66-in. cold tandem mill.
9. A 1-stand temper mill.
10. A 1-stand skin pass mill.
11. All auxiliaries.

Initial production (1963) will be 550,000 tons of steel ingots (400,000 tons of rolled flat products) for the automotive and shipbuilding industry.

Another plant under construction belongs to Usinas de Minas Gerais Co (Usiminas). It is located in the Rio Doce valley, 20 miles east of Acesita, on the same narrow gage railroad. Production will be similar to Cosipa's, with wider hot rolled bands and the same width cold rolled products.

Usiminas is building two blast furnaces with 23-ft hearths, a 120-in. plate mill, an 80-in. hot strip mill, and a 66-in. cold tandem mill. Part of the stock (40 per cent) belongs to a Japanese company and the rest to the government of Brazil, to the state of Minas Gerais and to private investors. Production will reach 550,000 tons of steel ingots at the first stage of production, with operation scheduled for 1963.

A third interesting project that is being executed is Cia. Ferro e Aço de Vitoria at Vitoria (state of Espirito Santo). This company is formed by German and Brazilian capital. The idea is to produce bars and shapes, employing at the beginning blooms from Usiminas, and later a blast furnace and a steel shop will be erected.

THE FUTURE OF STEEL PRODUCTION

The following table, taken from a study specially prepared by the Economic Commission for Latin America (ECLA) of the United Nations on the steel industry in Latin American countries, shows production and requirements, in 1965, of the countries located south of the U. S. in thousand tons of rolled products:[5]

	Production	*Consumption*
Argentina[a] (First assumption)	2,060	2,640
Argentina[b] (Second assumption)	2,400	2,640
Brazil	3,440	3,440
Colombia	270	545
Chile	506	440
Mexico[c]	1,650	2,090
Peru	110	210
Venezuela	390	935
Other countries	220	1,650
Total (First assumption Argentina)	8,646	11,950
(Second assumption Argentina)	8,986	

[a] One blast furnace only in San Nicolas.
[b] Two blast furnaces in San Nicolas.
[c] Corresponds to the period 1962–63, as there are no further plans.

As can be seen, there will still be a deficit of 3,300,000 tons of rolled steel (4,300,000 tons of ingots) in 1965. With the exception of Brazil and Chile all the other countries will have a deficit. We believe that even Brazil and Chile will import certain products and will not become entirely self-sufficient. The deficit will continue in 1975.

H. W. A. Waring puts the steel production of Latin America in 1975 at 18,700,000 tons of ingots and the consumption at 22,300,000 tons.

It is particularly interesting, when analyzing Latin American steel industry, to note the type of equipment that is assembled: it is all perfectly up-to-date. The significant part given to rolled flat products points to a balanced production and to the degree of industrialization that is being attained. For 1965 production of nearly 4,000,000 tons of flat products is foreseen.

Further, the importance already given to special steels and ferro-alloys production should be underlined. Also centrifugally cast iron pipes (a process that originated in Brazil with Ahrens, shortly after the first world war) and refractories of all types are being produced by Latin American industrial concerns.

Equipment imports have been financed, to a great

extent, by loans obtained from the U. S. and Europe. American material equipment has benefited through the excellent work of the Export-Import Bank of Washington, D. C., which has for this purpose granted loans of about $400,000,000 to Argentina, Brazil, Chile and Mexico. The financial effort made by the different countries is a huge one, as for each imported dollar, they have to invest in civil works, freight and other services, from $1.30 to $1.50 in their own currency. This leads us to believe that the total investment in steel industry, in Latin America, exceeds $1,200,000,000.

Technicians and manpower are being trained fast. "Know-how" has been given by experts engaged in the U. S. and in Europe and has also been acquired through training courses abroad as well as through the development of vocational training and by universities in the interested countries.

We do not know any better attempt to improve economic conditions in Latin America than by the development of its steel industry, and, as far as the U. S. is concerned, any more constructive effort than that of the Export-Import Bank of Washington, D. C.

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Discussion

PRESENTED BY

GORDON L. COX, Sales Manager, Freyn Dept., Koppers Co., Inc., Pittsburgh, Pa.

GEORGE HAVAS, Vice President, Kaiser Engineers International, Oakland, Calif.

Gordon L. Cox: With the possible exception of Mexico, the first coke blast furnace in Latin America was operated at Volta Redonda. It should be noted that General Soares was the leader in the planning, the designing and the operation of this, the largest steel plant in Latin America.

As General Soares has mentioned, the steel industry in Latin America, particularly in Brazil, has long been based on charcoal blast furnaces for producing iron. They are today's leaders in number of furnaces, size of furnaces and tonnage production of iron using charcoal produced with modern equipment under a planned recycle program to conserve the limited amount of presently known coking coal. We visited the Cia. Siderurgica Belgo-Mineria at Montevade and saw, "the world's greatest charcoal mill." We also saw new basic oxygen furnaces in operation. The plant management recognize the problems of a large charcoal operation and have directed considerable research toward developing efficient and economical charcoal stills which will recover the by-products.

In preparing feasibility studies for plants in Latin America, it is often difficult to justify the capital outlay required for a high tonnage flat product mill. The primary reason is that, in the initial phase of operations, the mill cannot be operated at anything near its actual capacity. It is interesting to note that Cia. de Acero del Pacifico in Chile started operations with a hand sheet mill. They now have a 3-stand tandem cold mill which started operation in February, 1960. The hand sheet mill, in turn, has been purchased by Acerias Paz del Rio in Colombia. While the mill is not modern, it is in good operating condition and will enable Paz del Rio to participate in the Colombian flat product market and should suffice until the market warrants a modern high-tonnage mill.

The Vitoria Mines railroad, which runs from the beautiful little coastal city of Vitoria to the iron mines at Itabira was originally built some 50 years ago with considerable loss of life from yellow fever. It was rebuilt in recent years by a U. S. firm. While it is still narrow gage with a few wood-burning locomotives for local switching, it is a modern road capable of handling high tonnages with diesel-electric locomotives. The road is owned by the Cia. Vale do Rio Doce, who also own the iron mines.

There is increasingly closer communication between the steelmakers of Latin America as is evidenced by the formation of the Latin American Institute for Iron and Steel with General Soares as President.

The extension of the close cooperation between Latin American steel producers, coupled with the continued strong interest of U. S. operators in the industrialization of Latin American countries should aid greatly, not only such industrialization, but also the closing of ties with our sister nations.

George Havas: The COSIPA plant, now under construction, is an interesting case study of an international and inter-American venture with financing being supplied by private capital, the state of Sao Paulo and the federal government of Brazil. The equipment is being obtained from the U. S. and several European countries. Detail design is being performed by Brazilian engineers to general design concepts established by U. S. engineers. Although most of the equipment is manufactured in Europe, every effort has been made to utilize American design and practice.

We agree completely with General Macedo Soares' thesis that the steel industry in Latin America, fed by enormous reserves of iron ore and the energy and intellect of its people, is on the threshold of a major expansion such as seen only in our country in the 1950's. ▲

REFRACTORY MAINTENANCE In Basic Oxygen Steelmaking Process

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The basic oxygen process, because of its relatively short heat time, places emphasis upon the establishment of good maintenance practice to prolong refractory life.

THE basic oxygen steelmaking process, like the open hearth furnace, electric furnace and acid bessemer converter, is a method of converting iron and ferrous scrap and or iron ore into steel of various grades.

Refractory maintenance to some degree is regularly practiced in every open hearth and electric furnace shop. All furnace bottoms are maintained by routine fettling or intermittent patching. It is standard practice to repair furnace walls with rather short downtime delays, and it is possible to patch or even to replace endwalls, backwalls, frontwalls or roofs, during a furnace campaign.

It has not been possible to replace portions of the working lining in the top blown basic oxygen furnace during a campaign. The average production rates, expressed in terms of tons of steel per hr, are conservatively two to three times that of a modern open hearth furnace utilizing basic roofs and oxygen lancing. Thus, furnace delays, in the basic oxygen process, are costly from the standpoint of steel production. This reason as much as any other has discouraged refractory maintenance as we normally think of it.

However, other techniques are used to reduce the refractory consumption per ton of steel produced and to balance the refractory life in the three main sections of these furnaces.

THE FURNACE

Figure 1 shows a typical basic oxygen furnace used by the various steel plants in the U. S. and Canada. There are three clearly defined sections of the furnace.

1. The bottom or hearth.
2. The barrel or body.
3. The cone, which can be flat or eccentric.

It is best that each of the three sections be discussed separately, describing the type of problems which have and do exist and the methods which have been and are being used to correct these problems.

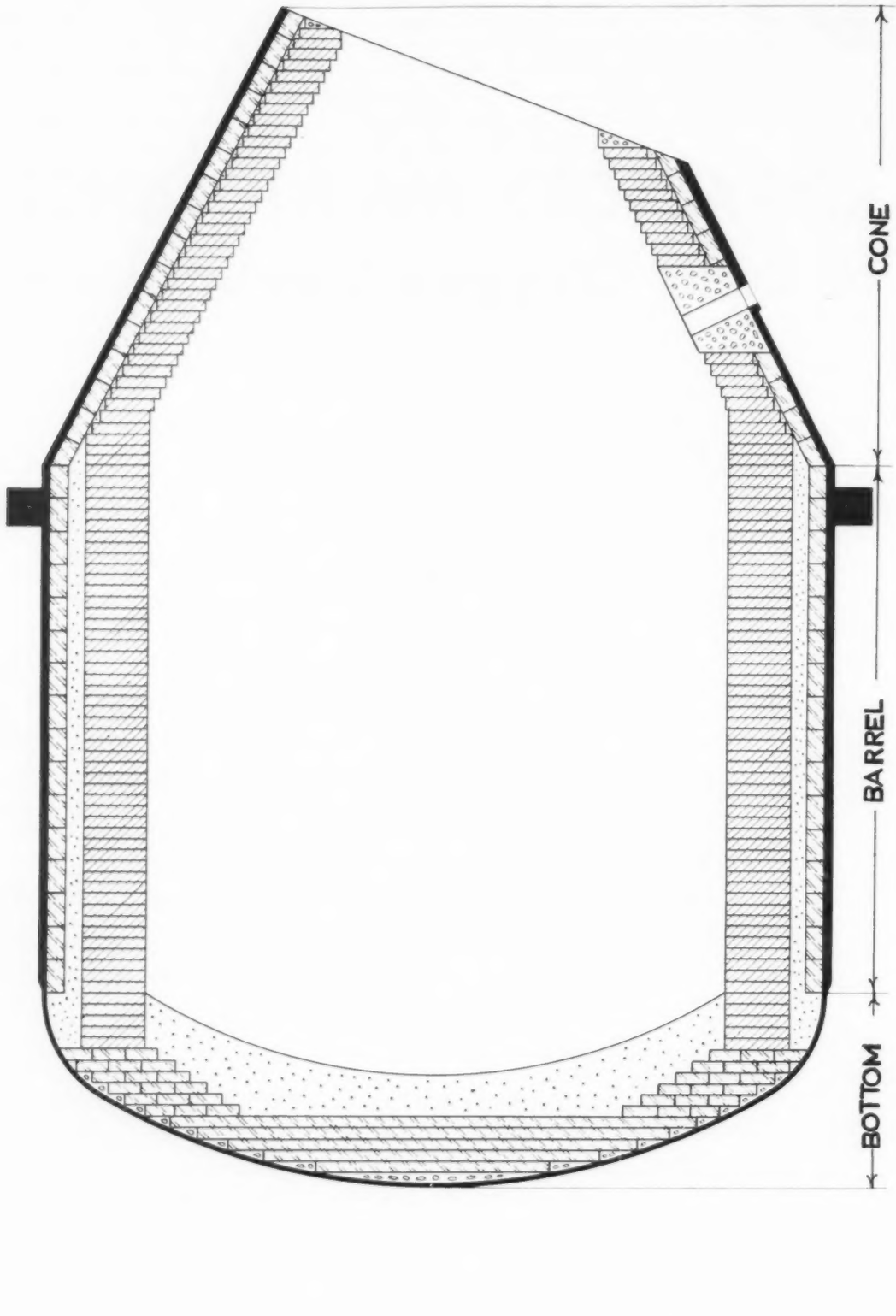
The bottom—The bottom is in two sections, which are the sub-bottom and the working bottom.

The sub-bottoms as originally installed in the vessels in the U. S. were replaced almost without exception after every furnace campaign. An improved design is being or will be used in every furnace shell which will accommodate an invert dome construction. The first was installed in April of 1958, and still remains intact today. All the new furnaces contracted to be built will utilize this construction. Properly designed, this sub-bottom also serves to key in the working bottom allowing removal of the working lining in the barrel and cone sections, while retaining the working bottom for one or more subsequent furnace campaigns. This feature should not be overlooked, since there probably will be campaigns during which very little of the working bottom is consumed and it is practical to retain the bottom intact for the subsequent campaign.

The working bottom properly installed gives no problems and seldom brings a furnace campaign to a conclusion.

When rammed hearths were used, there were occasions when part of it was lost during a furnace campaign. Quite often the failure was attributed to improper burn-in, but this loss was of minor concern because this part of the furnace can be patched. Tar-bonded

Figure 1 — Although many ramming mixtures have been used, tar-bonded, dolomite-magnesite ramming material is the best patching material for repairing the working bottom of the basic oxygen furnace.



dolomite-magnesite ramming material shoveled into a hole and allowed to burn-in is the best patching material; however, mixtures of dolomite, dolomite-magnesite (not tar-bonded), and magnesite ramming mixtures of the 80, 85 and 92 per cent grades have been used with good success. During the furnace operation the bottom is always protected, by the metal, from the slag and oxygen impingement and is the area of least refractory wear.

The barrel or body—One section or another of the working lining of the barrel or body of the furnace was the limiting factor of the early furnace campaigns at most plants in the U. S. and Canada. More specifically, the failure was in one or both of two general areas:

1. At the slag line or just above, and most generally on the trunnion sides.
2. On the charge side.

Relatively long blowing times, variations in slag control and frequency of furnace delays subject the lining to excessive erosion at or just above the slag line. If the eroded area is confined and deep, patching has been done, but with limited success. Dolomite, dolomite-magnesite combinations and high MgO ramming mixtures gunned into place have been used, but they must be given time to sinter in place if they are to be at all effective. This maintenance technique is used primarily in shops having three vessels, where furnace availability is not as critical as in 2-furnace shops, since its value is very questionable.

There are seven basic oxygen furnace process shops on the North American continent. In five of these, scrap and hot metal are charged from the same side of the vessel, and subject the lower cone and upper barrel lining to abuse. In one shop the scrap and hot metal charge strikes the furnace bottom, whereas in the seventh shop, the scrap and hot metal are charged from opposite sides. Later data may indicate which charging operation causes the most severe lining wear.

The degree of mechanical abuse depends upon the size and type of scrap charged and the angle of impingement. Scouring and or cutting of the lining by hot metal charge is most severe when the angle of impingement is greatest.

Patching of this area has been accomplished with relatively good success. The most successful technique has been to float in a patch with high MgO ramming materials. The patch is only successful when properly dried, covered with steel plates over which 2000 to 4000 lb of hot metal is allowed to freeze. This provides protection for the patch until it can be sintered during a furnace heat. A patch of this type has lasted up to 24 hr.

A more satisfactory method to protect this critical area has been common practice in one shop for almost a year. The belly maintenance program is as follows: 1000 lb of burnt lime is charged to the vessel after each slag off and before the scrap charge. The vessel is rolled down so as to cover and coat the belly with the lime. The vessel is held in this position for one to two min or longer if time is available, otherwise, the vessel is promptly positioned for scrap charge which proceeds immediately.

An alternate method is to keep 1000 to 2000 lb of slag in the vessel from the previous heat, to which the 1000 lb of lime is added and the same procedure as above follows.

The maintenance program, started shortly after the beginning of a furnace campaign, provides a cushion to protect the belly against scrap and hot metal charge on each heat.

Design of the lining as originally installed can assist in balancing lining consumption. A heavier lining for one third of the circumference on the charge side has been used with satisfactory results. This is commonly referred to as a pilaster or wear pad. This design provides about five in. of additional brick in the area of greater wear.

Burned magnesite brick, with its better physical strength and excellent resistance to slag and metal penetration, would be the natural choice for the belly area. Products commercially available today lack the necessary resistance to thermal shock. However, recently developed products, especially those of the 98 per cent MgO type, indicate that a satisfactory burned magnesite brick may soon be available.

The cone—The cone section of the furnace becomes the limiting factor, primarily when higher operating rates are attained. Maintenance of the cone section in localized areas has been possible with very limited success. Up to the present time, no patching material has been developed which will successfully adhere to tar-bonded brick. Thus, unless there is a pocket or hole, patching material will not adhere to a generalized area.

When the tar-bonded brick have been consumed and the 4½-in. tank lining is exposed, the maintenance materials will adhere to the burned magnesite brick. In addition to the previously mentioned maintenance materials, a chrome-magnesite slurry refractory has been used. Since only a 4½-in. tank lining is generally used, attempts to operate the furnace for extended periods of time, even with gunning maintenance after each heat, is a questionable practice since the cone shell becomes excessively hot.

In one shop, a portion of the cone section has been replaced during a furnace campaign. This was done after 150 to 170 heats, by allowing the furnace to cool to almost room temperature, after which the furnace was reheated to properly burn-in the new tar-bonded brick. An additional 50 to 70 heats was obtained from the furnace lining.

If the thickness of the cone brick is increased when the cone becomes the limiting factor, the furnace lining can be balanced. This has been found to be the best solution, and is the case history in every shop.

SUMMARY

Under existing conditions, maintenance will mean complete replacement of the furnace lining, with the possible exception of the working bottom.

A balanced furnace lining, which will produce the lowest cost of refractory per net ton of steel produced, will depend upon furnace lining construction details and the use of various types of refractory products in critical zones. We might correctly say that a zoned lining appears to be the basic oxygen furnace lining of the future. ▲

Lubrication of

REPUBLIC Steel Corp.'s 45-in. slabbing mill is a 2-high, electrically driven reversing mill, located in the Cleveland district steel plant.

In the design of the mill, lubrication systems were provided to handle the various types of lubricants which would be required. Flexible hose for oil and grease connections was used wherever possible. Shields and guards were installed to give protection to the hose and other oil and grease piping.

There are five cranes servicing this mill: a 75-ton mill crane, a 25-ton mill crane and three 60-ton slab yard cranes. These cranes have a mechanically driven, centralized lubrication system on each individual bridge and trolley.

To lubricate the delivery roll bearings of the ingot transfer cars, centralized hand grease pumps were originally mounted on the frames of the cars. Due to the extreme heat from the ingots, the buggy-mounted grease pumps soon became inoperative and were replaced by fittings that permit the use of either a portable hand or air pump assembly. Motors for the oil pumps used to lubricate the buggy drive gears were eliminated by chain and sprocket arrangements activating the pumps from the main car drives.

All centralized grease systems are served by electrically driven hydraulic barrel pumps mounted on 400-lb drum covers. Each system has its own fully automatic control panel complete with timer, operating lights, pressure switch, recorder and valves. Each control panel timer is set to handle the required amount of lubricant for that particular system. The range in time of the various systems is from two min "on" and three min "off" on one system, to ten min "on" and six hr "off" on another system. An electric timer starts the pump which is turned off after the cycle is completed by a microswitch located on the reverser.

The mill's separate grease systems are grouped as follows:

System No. 1—Ingot receiving table, ingot lifting device (for weighing) and ingot scale and mill approach tables.
System No. 2—Front mill table, entry manipulator and four individual drive rolls.
System No. 3—Mill slides, feed rolls and spindle trunnions.
System No. 4—Mill screws and pressure blocks.
System No. 5—Vertical edger screws, pressure blocks, bearings and slides.
System No. 6—Back mill table, delivery manipulator and four individual drive rolls.
System No. 7—Mill runout and scarfing machine approach tables.
System No. 8—Scarfing machine delivery and shear entry tables and crop hoist.
System No. 9—Shear slides and bearings.
System No. 10—Shear pull-back table.
System No. 11—Shear delivery and slab scale tables and shear gage.
System No. 12—Cradle side of piler tables.
System No. 13—Drive side and pusher mechanism of piler tables.

The mill roll necks are equipped with fiber composition bearings which are cooled and lubricated by filtered, recirculating city water. Our experience indicates that city water alone does not provide satisfactory lubrication of the bearings under heavy mill operating conditions. Consideration is being given to the installation of an automatic centralized oil spray system to provide additional lubrication for these bearings.

Originally a gravity feed oil system for slipper lubrication was installed on the mill spindles. An excessive amount of oil was consumed resulting in a poor housekeeping condition and a serious fire hazard. To correct these conditions, experiments were carried out with automatic lubricators, which materially reduced the oil consumption. However, a serious anchoring problem was encountered. To keep the lubricators secure on the spindles, the clamping arrangement was supplemented by keying the lubricators to the spindles, and this arrangement has proved adequate. The lubricator is a self-contained unit with an oil reservoir, and a fully automatic pump activated by the reversing action of the spindle through the inertia of a weighted piston. The pump feeds a series type distribution valve which meters a controlled amount of lubricant to outlets through hose or tubing.

There are three fully automatic circulating extreme pressure gear oil systems for the tables and drives. The gear oils used are noncorrosive, oxidation and foam inhibited extreme pressure lead naphthenate type having a low pour point.

System No. 1 supplies a 2400 SSU at 100 F, extreme pressure gear oil, and system No. 2 supplies an 1800 SSU at 100 F, extreme pressure gear oil. Each of these circulating gear oil systems consists of two 220 gpm positive displacement gear type pumps (one active and the other a standby) relief valves, regulators and a 200-gal air cushioned balance tank 67-in. high with a 30-in. diam. Also included are a motor driven stainless steel disk type filter of the continual self-cleaning type, 3 ft in diameter and 7-ft high which removes particles larger than 0.008 in. in diameter, a 2-stage heat exchanger operating on city water and the necessary lights and alarms located near the pumps and the ends of the lines. The drive lubricating system consists of one 7500-gal tank, thermometer, steam coils, gage board and floating suction. The table lubrication system is the same as the drive lubrication system except it has two 7500-gal tanks manifolded to provide regular periodic rest periods for settling out of water and dirt contamination.

Republic Steel's 45-In. Slab Mill

by W. J. RODENBERGER,
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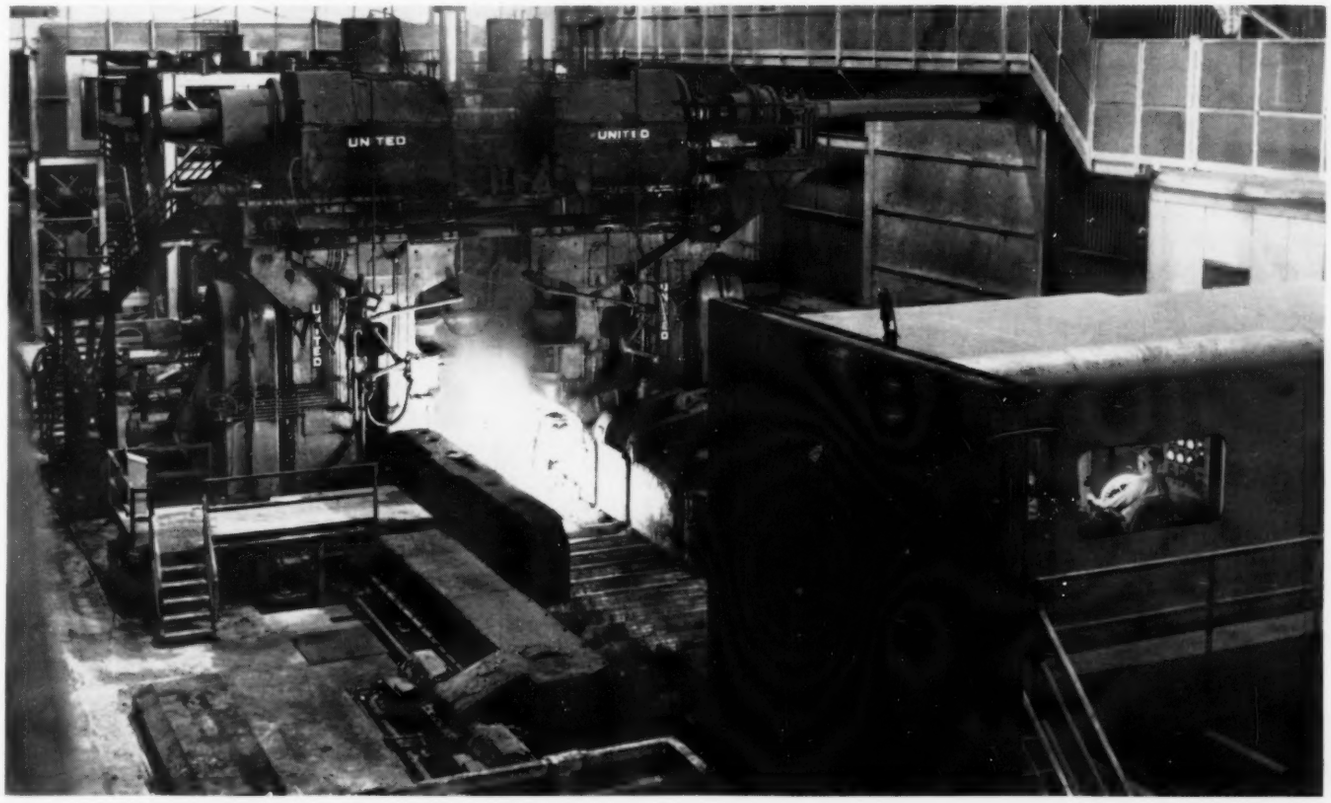
Preplanning and proper installation together with operation re-evaluation are important factors in the development of an adequate lubrication system.

These two systems are piped and valved in such a way that one 150-gphr centrifuge with an electric heater and pumps can remove foreign material from the oil of either system. The centrifuge has proved very beneficial in removing contaminates from the oil.

In the original lubrication design, the gear oil system and the grease systems overlap. The automatic grease systems with one hr timers lubricate the drive bearings, lineshaft bearings and table roll bearings. The circulating oil system maintains an oil bath for splash lubrication of all gears, except those in the front and back mill tables. These are lubricated by oil sprays that do not require maintaining a fixed oil level. Such a system is used to reduce the interval of time that the oil is subjected to the elevated temperatures. Consequently, the rate of oxidation is reduced. However the oil filter

Figure 1 — Use of flexible hose connections has reduced lubrication line failures by a significant factor on Republic Steel Corp.'s 45-in. slabbing mill.



soon plugged up as a result of contamination in the oil system from soap from the grease system. Temporary relief has been obtained by extending the time cycle from one to two or more hr and by operating the centrifuge continuously. Permanent improvement is planned through the complete separation of the two systems. The grease system will be used on the idle end-table roller bearings only. The recirculating oil system piping will be altered so that it will serve all drive lineshafts, and roll-drive-end bearings, as well as all the gears. This includes everything inside the table drive gear and lineshaft case.

The third system is a self-contained circulating extreme pressure gear oil system, delivering a 2400 SSU at 100 F, extreme pressure gear oil. It consists of two 45 gpm rotary-piston, positive displacement, variable-volume, control pumps (one active, the other a standby); a line strainer, steam coils, regulator, thermometer, sight feeds, flow indicators and the necessary lights and alarms.

There is a 300 SSU at 100 F, rust and oxidation inhibited circulating oil system serving the 13,500-kw main generator set which consists of a flywheel, a 9000-hp wound-rotor motor, two 1750-kw and four 2500-kw generators running at approximately 500 rpm which supply all the variable voltage power for two 6000-hp mill motors and the 4000-hp vertical edger motor.

This oil system consists of: one 2500-gal tank with steam coils, thermometer, regulator, gage board and floating suction; two 70-gpm gear type pumps, a continuously self-cleaning motor operated strainer, one air cushioned surge tank, 18-in. diam x 36-in. high and a single pass heat exchanger with the necessary lights and alarms located in the oil room and at the generator set.

The above generator equipment, weighing 287 tons, has seven lift pumps that facilitate easier starting. The bearings are protected from over heating, because of lack of oil or any other reason by thermo-relay switches, that trip at 96 C and sound an alarm for the motor room attendant.

There are five hydraulic systems in the mill, some using 20 per cent soluble oil, others using mineral oil or water. A 1300-psi hydraulic roll balance system and a 1000-psi hydraulic spindle carrier and edger roll balance system are served by a central pumping station from one 1000-gal reservoir with 20 per cent soluble oil. This station is so valved that any one of three 24.4 gpm motor-driven triplex piston pumps may be used on either of the above systems with one pump as a standby for either system. The line pressure is determined by the use of a 138-gal weight loaded accumulator using limit switches that start and stop the pumps. These limit switches are so wired as to set off lights and alarms in the roller's pulpit in cases of trouble with the system.

The 300-ton down and upcut shear hydraulic system, operated at 1000 psi, controls the position at which the top head stops, cushions the return of the bottom head and provides pressure for the gag cylinder. This system has a 200-gal 20 per cent soluble oil reservoir. The line pressure is maintained by the use of one 5.45 gpm triplex piston pump with an additional pump as a standby. The line pressure is determined by a 70-gal weight loaded accumulator using limit switches to start and stop the pump as needed. The limit switches are wired to set off lights and alarms in the shearman's pulpit.

A rupture occurred in the shear gag cylinder during frigid weather due to the freezing of the 20 per cent soluble oil used as the hydraulic medium. This condition, brought about by the limited action in the cylinder, required the installation of a heating tracer line. No such difficulty with the mill and edger cylinders, also operating on 20 per cent soluble oil, was encountered undoubtedly due to more frequent operation of the hydraulic system.

The crop door and slab scale hydraulic system uses a 300-SSU at 100 F, rust and oxidation-inhibited turbine oil. This system consists of: one 900-gal reservoir and two 60-gpm motor-driven vane-type pumps, one used as a standby. Each pump has an 80-mesh strainer and magnetic-type filter, one pneumatic piston-type accumulator and necessary valving.

The hydraulic-operated centering guides for the scarfing machine entry approach table are operated by one 4-stage 325-gpm centrifugal pump using city water, with an additional pump used as a standby. Since trouble was encountered with the vertical edger slides, or wearing plates, due to the extreme weight on these surfaces the slides have been redesigned for improved lubrication.

A hand operated 12-lb oil pump supplies an extreme pressure gear oil to the upper and lower carriages of the automatic desurfacing machine. A motor-operated 12-lb centralized grease pump supplies lubricant for the horizontal and vertical slides.

In spite of the extensive research and study preceding the design and installation of lubrication facilities for this mill and its auxiliary equipment, various unforeseen conditions have since necessitated re-evaluation of, and changes to, the original installation. However, much of the preplanning and preliminary preparation has paid dividends.

Experience has proved that:

1. Flexible hose has a distinct advantage over rigid connections. This means of lubricant distribution successfully absorbs impact and tension which are the major contributors to tubing line failures.
2. Oil and grease lines should be protected from external damage by the use of properly designed guards or shields in areas where excessive damage is apt to occur.
3. Pumping units and reservoirs should not be placed where they will be subjected to excessive heat.
4. Composition bearings must have constant water pressure and flow during mill operation.
5. Distribution and application equipment which is subjected to rapid acceleration or deceleration of the equipment upon which it is mounted must be securely anchored, requiring specially designed fasteners in some cases.
6. Frequent operation of soluble oil systems in cold weather aids in preventing freezing of the emulsion.

In the final analysis, it must be thoroughly understood that re-evaluation, modification and improvement of all phases of lubrication continue as prime responsibilities of the lubrication engineer throughout the life of the mill.

Discussion

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E. J. Gesdorf: One of the most dangerous enemies of all types of lubricating equipment in steel mills is the damage to the lines resulting from the severe use and abuse of the equipment in obtaining maximum production. We noted with interest that flexible hose was used extensively for oil and grease connections on Republic Steel's slabbing mill. There seems to be a trend in the mills toward more extensive use of hose in lubricating systems. Is hose being used for supply and discharge lines on the centralized systems and what is the bursting pressure of the hose for these applications?

Shields and guards for the lubrication equipment and piping is worthy of serious consideration. The practice has been and still is on steel mill installations to "hang" the lubricating system on in the field. This dictates the need for shields and guards and they should be of the indestructible type and generously used. It is hoped that as time goes on a trend for including the lubricating system in the mill design will manifest itself. Much could be done in the design of a mill to give better protection to the lubricating equipment.

Can Mr. Rodenberger give us the bearing life in tons of steel rolled for the fabric bearings of the 45-in. slabbing mill?

It was especially interesting to learn that some thought is being given to eliminating the grease system from the lineshaft bearings, drive bearings and table roll bearings on mill tables and replacing it with the circulating oil system. I am wondering if Mr. Rodenberger would be kind enough to explain what thought has been given to the seals on the table roll bearings to permit the use of a circulating oil system without excessive oil loss.

Another school of thought not only eliminates the contamination resulting from overlapping of grease and oil systems but also eliminates the water and scale problem. This train of thought favors eliminating the circulating oil system and using one centralized lubricating system to inject grease into all the bearings and spray grease onto the gears. Successful installations of this type, which are highly efficient and economical, are in service in several mills today.

W. J. Rodenberger: We use hose on grease systems for supply and discharge lines and in any location where vibration may be excessive. We use hose on hydraulic systems for similar conditions and for terminal connections at valves and cylinders to provide a cushion for surge pressures. On circulating oil systems, hoses are used principally on flexible connections although hose may be used in locations of vibration.

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W. H. Geary: The author's statement that preplanning and preliminary preparation concerning lubrication systems have paid dividends is important. This is a very logical consequence of preparation in any endeavor, yet our industry still needs much prodding about the importance of the early consideration of lubrication requirements for a new facility.

Selection of flexible hose for bearing lead lines not only to accommodate the moving parts but to absorb shock should be high-lighted. The preplanning should include the consideration of many details of good maintenance practice rather than dismiss lubrication systems as a broad generality to be tolerated before "start-up day" and condemned-there-after.

The author mentioned a change in the lubrication systems on the front and back mill tables necessitated by grease contaminating the oil filters in the extreme pressure gear oil system. The plan at present is to revamp the grease system so that it serves just the bearings on the roll ends opposite the drive side. The oil system is to be repiped to include the lineshaft bearings, drive bearings and the bearings on the driven end of the rolls as well as the gears already on the circulating system. Have you considered the possibility of just splitting the grease system and with a separate pump, use the gear oil through the existing feeders and piping for the drive side? If this has been considered, what were the reasons for selecting the expansion of the circulating system as the solution to this problem?

W. J. Rodenberger: We have considered the possibility of supplying gear oil through the existing grease distribution system, but have chosen to utilize the circulating oil system because pumps and auxiliary equipment were of sufficient capacity to take care of the additional requirements. This also makes possible the utilization of the grease feeder blocks for other purposes. Another consideration which would favor the

soon plugged up as a result of contamination in the oil system from soap from the grease system. Temporary relief has been obtained by extending the time cycle from one to two or more hr and by operating the centrifuge continuously. Permanent improvement is planned through the complete separation of the two systems. The grease system will be used on the idle end-table roller bearings only. The recirculating oil system piping will be altered so that it will serve all drive lineshafts, and roll-drive-end bearings, as well as all the gears. This includes everything inside the table drive gear and lineshaft case.

The third system is a self-contained circulating extreme pressure gear oil system, delivering a 2400 SSU at 100 F, extreme pressure gear oil. It consists of two 45 gpm rotary-piston, positive displacement, variable-volume, control pumps (one active, the other a standby); a line strainer, steam coils, regulator, thermometer, sight feeds, flow indicators and the necessary lights and alarms.

There is a 300 SSU at 100 F, rust and oxidation inhibited circulating oil system serving the 13,500-kw main generator set which consists of a flywheel, a 9000-hp wound-rotor motor, two 1750-kw and four 2500-kw generators running at approximately 500 rpm which supply all the variable voltage power for two 6000-hp mill motors and the 4000-hp vertical edger motor.

This oil system consists of: one 2500-gal tank with steam coils, thermometer, regulator, gage board and floating suction; two 70-gpm gear type pumps, a continuously self-cleaning motor operated strainer, one air cushioned surge tank, 18-in. diam x 36-in. high and a single pass heat exchanger with the necessary lights and alarms located in the oil room and at the generator set.

The above generator equipment, weighing 287 tons, has seven lift pumps that facilitate easier starting. The bearings are protected from over heating, because of lack of oil or any other reason by thermo-relay switches, that trip at 96 C and sound an alarm for the motor room attendant.

There are five hydraulic systems in the mill, some using 20 per cent soluble oil, others using mineral oil or water. A 1300-psi hydraulic roll balance system and a 1000-psi hydraulic spindle carrier and edger roll balance system are served by a central pumping station from one 1000-gal reservoir with 20 per cent soluble oil. This station is so valved that any one of three 24.4 gpm motor-driven triplex piston pumps may be used on either of the above systems with one pump as a standby for either system. The line pressure is determined by the use of a 138-gal weight loaded accumulator using limit switches that start and stop the pumps. These limit switches are so wired as to set off lights and alarms in the roller's pulpit in cases of trouble with the system.

The 300-ton down and upcut shear hydraulic system, operated at 1000 psi, controls the position at which the top head stops, cushions the return of the bottom head and provides pressure for the gag cylinder. This system has a 200-gal 20 per cent soluble oil reservoir. The line pressure is maintained by the use of one 5.45 gpm triplex piston pump with an additional pump as a standby. The line pressure is determined by a 70-gal weight loaded accumulator using limit switches to start and stop the pump as needed. The limit switches are wired to set off lights and alarms in the shearman's pulpit.

A rupture occurred in the shear gag cylinder during frigid weather due to the freezing of the 20 per cent soluble oil used as the hydraulic medium. This condition, brought about by the limited action in the cylinder, required the installation of a heating tracer line. No such difficulty with the mill and edger cylinders, also operating on 20 per cent soluble oil, was encountered undoubtedly due to more frequent operation of the hydraulic system.

The crop door and slab scale hydraulic system uses a 300-SSU at 100 F, rust and oxidation-inhibited turbine oil. This system consists of: one 900-gal reservoir and two 60-gpm motor-driven vane-type pumps, one used as a standby. Each pump has an 80-mesh strainer and magnetic-type filter, one pneumatic piston-type accumulator and necessary valving.

The hydraulic-operated centering guides for the scarfing machine entry approach table are operated by one 4-stage 325-gpm centrifugal pump using city water, with an additional pump used as a standby. Since trouble was encountered with the vertical edger slides, or wearing plates, due to the extreme weight on these surfaces the slides have been redesigned for improved lubrication.

A hand operated 12-lb oil pump supplies an extreme pressure gear oil to the upper and lower carriages of the automatic desurfacing machine. A motor-operated 12-lb centralized grease pump supplies lubricant for the horizontal and vertical slides.

In spite of the extensive research and study preceding the design and installation of lubrication facilities for this mill and its auxiliary equipment, various unforeseen conditions have since necessitated re-evaluation of, and changes to, the original installation. However, much of the preplanning and preliminary preparation has paid dividends.

Experience has proved that:

1. Flexible hose has a distinct advantage over rigid connections. This means of lubricant distribution successfully absorbs impact and tension which are the major contributors to tubing line failures.
2. Oil and grease lines should be protected from external damage by the use of properly designed guards or shields in areas where excessive damage is apt to occur.
3. Pumping units and reservoirs should not be placed where they will be subjected to excessive heat.
4. Composition bearings must have constant water pressure and flow during mill operation.
5. Distribution and application equipment which is subjected to rapid acceleration or deceleration of the equipment upon which it is mounted must be securely anchored, requiring specially designed fasteners in some cases.
6. Frequent operation of soluble oil systems in cold weather aids in preventing freezing of the emulsion.

In the final analysis, it must be thoroughly understood that re-evaluation, modification and improvement of all phases of lubrication continue as prime responsibilities of the lubrication engineer throughout the life of the mill.

Discussion

PRESENTED BY

E. J. GESDORF, Senior Application Engineer, The Farval Corp., Cleveland, Ohio

W. J. RODENBERGER, Lubrication Engineer, Cleveland District, Republic Steel Corp., Cleveland, Ohio

W. H. GEARY, Sales Engineer, Ritter Engineering Co., Pittsburgh, Pa.

J. R. WICOFF, Lubrication Engineer, The Youngstown Sheet and Tube Co., East Chicago, Ind.

W. W. BEDORTHA, Superintendent Mechanical Maintenance, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

E. J. Gesdorf: One of the most dangerous enemies of all types of lubricating equipment in steel mills is the damage to the lines resulting from the severe use and abuse of the equipment in obtaining maximum production. We noted with interest that flexible hose was used extensively for oil and grease connections on Republic Steel's slabbing mill. There seems to be a trend in the mills toward more extensive use of hose in lubricating systems. Is hose being used for supply and discharge lines on the centralized systems and what is the bursting pressure of the hose for these applications?

Shields and guards for the lubrication equipment and piping is worthy of serious consideration. The practice has been and still is on steel mill installations to "hang" the lubricating system on in the field. This dictates the need for shields and guards and they should be of the indestructible type and generously used. It is hoped that as time goes on a trend for including the lubricating system in the mill design will manifest itself. Much could be done in the design of a mill to give better protection to the lubricating equipment.

Can Mr. Rodenberger give us the bearing life in tons of steel rolled for the fabric bearings of the 45-in. slabbing mill?

It was especially interesting to learn that some thought is being given to eliminating the grease system from the lineshaft bearings, drive bearings and table roll bearings on mill tables and replacing it with the circulating oil system. I am wondering if Mr. Rodenberger would be kind enough to explain what thought has been given to the seals on the table roll bearings to permit the use of a circulating oil system without excessive oil loss.

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circulating oil system was the fact that additional pumps would have had to have been purchased to provide sufficient oil pressure to operate the feeder blocks.

J. R. Wicoff: We have a contamination problem on a similar mill. The circulating system serves the mill approach and runout tables, and not the mill tables proper; the lineshaft bearings and the table roll neck bearings are served by the grease system and the gears are lubricated with oil.

The circulating system serves to insure that the table gear box is full of oil entering through a sight flow gage and leaving the gear box over a dam to the drain line.

We experienced difficulties as the author did with plugged filters. In addition to this we experienced severe foaming in the supply tank which caused overflow.

The circulating system was valved off at the inlet to the table, leaving the drain over a dam intact. Periodically this valve from the circulating system is opened to bring the oil up to level if necessary. The circulating system also serves other units, so that it runs continuously.

This means the table gears are lubricated with a mixture of grease and oil, and we have found that after six years of operation in this manner, the consistency of this mixture is still such that it does an excellent job of lubricating the gears.

Another difficulty with the circulating system was the great amount of oil that remained in bank while the pumps were running. This oil all drained back when the pumps were shut off. This system has two tanks, one intended to be at rest to allow the conditioning of the oil. Actually, we had to employ both tanks while running, which points up the desirability of taking into account the amount of oil being held over head when running in determining the size of the tank. It is usual practice to allow a certain factor in relation to the capacity of the pumps per min, but the amount of drainback should have prime consideration in determining the size of tanks.

W. J. Rodenberger: Mr. Wicoff's comments on the foaming of oil in circulating systems brings out a condition which has existed on many oil reservoirs. On this mill the return lines enter through the side of the tank resulting in lower aeration and less foaming.

W. W. Bedortha: At Great Lakes Steel Corp., we have a slabbing mill which is comparable to this mill at Cleveland, and we have encountered many problems of a similar nature.

On mill roll necks, does your present system depend entirely on water, and what is the pressure? What was your experience in using water alone, and what was done to correct or improve these conditions?

On the slipper lubrication of mill spindles, what mechanical difficulties were encountered on installation and in changing mill spindles? What mechanical maintenance have you encountered with the oil pumps?

On the vertical edger, what was done in redesign to the wearing plates (bottom) to improve lubrication? Was any distortion noted on the housing, and if so what was done to correct it?

Have you had any experience with using anti-freeze in your water soluble oil system?

W. J. Rodenberger: The water pressure at the mill is approximately 35 psi. The volume of water is of more importance than the pressure at which it is delivered. The application of additional lubrication for these bearings has been studied but no additional quantity has been applied.

The spindle lubricator, when originally installed, developed slippage between the lubricator and the spindle as a result of inertia at times of mill reversal. This condition was overcome by keying the lubricator to the spindle and adding an additional clamping device. So far, no trouble has been experienced on the lubricator pumps except from the standpoint of lower viscosity lubricant requirements in cold weather. No problem has been encountered with spindle lubricators when changing spindles as the lubricator is basically a part of the spindle.

No distortion has been experienced on the housings of the vertical edger. The support slides had the grease grooves changed from the form of a double X to a multiple H with the crossbar of the H continuous for the length of the slide. A pocket for grease storage and supply was provided at the center of the slide length. Shields have been added to cover and wipe dirt from these support slides. No changes have been made on the side wear plates although jib mounted wear plates with adequate grease supply are being studied for possible benefits.

Experience with anti-freeze has been very limited, and we have found varying reactions with different permanent type anti-freezes. No experience has been obtained on the alcohol types. The soluble oil systems on this mill have been principally protected by the use of steam heat. ▲

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Pressurization of Idle Coke Ovens

by A. D. SHATTUCK, Superintendent, Coke Oven Plant,
Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

During enforced periods of idleness, coke ovens can be kept in readiness for immediate production by a suitable pressurization program. . . . this paper was presented before the Eastern States Blast Furnace and Coke Oven Association Winter Meeting in Pittsburgh, Pa., as well as the AISE Detroit Section Meeting.

TODAY'S modernization of blast furnace practice is being given top priority by the steel industry. The advent of totally prepared burdens for much higher as well as larger furnaces, the use of elevated blast temperatures, automatic controls keeping temperatures straight-line, addition of moisture and oxygen to the blast, high top pressures, complete uniformity of blowing rates with much higher capacity blowing engines and other innovations still in design and experimental stages point up the necessity of the by-product coking industry supplying the furnaces with uniform and nearly perfect coke that is required for high efficiency operation.

As the blast furnace operator is moving toward modernization, the coking industry is moving toward improvement of its product in an effort to adequately supply the furnace operator. Much thought is being given to the use of better coals in the mix, and testing facilities are being greatly improved. Research in selective grinding of individual coals has progressed tremendously. Mining practice is being improved in an effort to supply lower ash and lower sulphur coals. Better methods of screening and handling of coke are being investigated. Automatic bulk density control systems are in service in several plants. Operators everywhere are striving toward uniformity of coke-oven operating practices to assure a uniform product for the furnaces. Engineers and builders of coke ovens are striving constantly to improve oven design as well as machinery and other auxiliaries necessary to smoothly operating plants. Thought is being given to larger ovens, the wisdom of which will no doubt be proved.

With this emphasis on better blast furnace coking practice, has come a new look from operating managements with respect to proper maintenance and resultant lengthening of life expectancy of existing batteries of coke ovens. Many batteries of ovens have been prematurely pushed to rubble through improper maintenance coupled with abnormal operating conditions. Frequently, urgently needed yet minor repairs have been postponed to satisfy coke needs and costs. The coke supplies of many large steel producing companies have not been equal to the requirements of their blast furnaces and coking cycles have been far in excess of the builders' specifications. In recent years, many plants have increased the length of coking cycle to a realistic figure, and better coals have been made available. Repairs have been permitted on a current as-needed basis. In some cases for the first time, erection of new coking facilities, increasing available supply to an excess of requirements, is becoming an actuality.

One of the most difficult problems confronting the coke-plant operator is the maintenance of the batteries when economic conditions, work stoppages or other causes require a prolonged interruption of normal operations. A scheduled shutdown calls for weeks of planning of such matters as proper and safe handling of equipment, the scheduling of forces, accumulation of supplies and disposition of inventories. When the shutdown is unscheduled, in the case of a work stoppage, the inability of management to plan and prepare for the interruption causes a problem which perplexes and worries the coke-plant operator. In such a situation, normal forces of employees may vanish leaving a few supervisors on hand to prevent disaster, and through their efforts assure safe and proper handling of coke-oven plants. Although results of such occasions are most often intangible, without a means of measuring the actual loss of life to ovens, it is recognized by coke-plant personnel that substantial loss of longevity occurs. For the past several years, much thought has been given to the measures that are best for the protection of coke ovens and other coke plant facilities when shutdowns may be necessary because of work stoppages or economic curtailments.

In the early part of 1958 Great Lakes Steel Corp. was confronted with these problems. Somewhat different than during times of labor unrest, however, was the fact that exactly 50 per cent of the producing capacity of the four batteries of coke ovens was required. Unlike most coke plants, the coke ovens are divided into two completely integrated plants, each containing two batteries, complete by-product facilities and coal and coke handling equipment. Unfortunately they are approximately one half mile apart. The surplus coke-oven gas mains from the two plants unite to admit gas to the common booster station which pumps the cleaned gas to the steel plant approximately three miles distant. The No. 2 plant contains the light oil distillation unit as well as the ammonium sulphate producing unit, and crude light oil and concentrated ammonia liquor produced at the No. 1 plant are pumped to the No. 2 plant for processing. The coke producing capacities of the two plants are practically identical, each normally on a 17-hr coking cycle carbonize 3650 tons of coal per day.

As the output of either of the two plants would fulfill coke requirements and because coke produced over a 17-hr coking cycle is much superior in all respects to coke produced over a 34-hr cycle for blast furnace use, the decision to bank one of the plants was more or less automatic. Comparative cost studies with the possibility of an approximate 47 per cent labor and utility saving substantiated the decision. The No. 2 plant consisting of the two newer batteries was felt to be in better condition to bank, being but one and three years old respectively. However, due to inability to process the ammonia liquor at the No. 1 plant and due to close proximity of light oil distillation facilities to the No. 2 plant, the decision was made to bank the No. 1 plant. These batteries of 73 ovens each were placed in operation in October 1938 and January, 1939 respectively. Although well maintained over the 20-year period, a short coking cycle, year after year, of 14 hr and 45 min, coupled with somewhat more than average abnormal rates of operation due to work stoppages, many of which were without advance notice, showed they were fast approaching the time when substantial repairs would be necessary. Oven door frames, door structures and buckstays were warped and in need of replacement. Coke side liner brick were breaking adjacent to the end, and in some cases the second flue, allowing the joints to widen. With the frames and bowed buckstays moving out, this created a constant patching program. The floors, as witnessed after pushing the batteries empty early in the strike of 1949, would probably not stand the abuse of either pushing the ovens empty again or leaving coke in the ovens for a matter of weeks, without repouring. All concerned were in agreement that any measures taken which did not assure complete retention of patching and carbon buildup within the oven chamber could delay start-up of the batteries a matter of a week to ten days with full production delayed possibly several weeks. Carbon buildup occurs during the normal coking process in all properly operated batteries, grows over the entire surface of the oven floor, creating a monolithic smooth surface enabling ovens to push easily, tends to seal leaking joints, heals rough spots and spalls and is most valuable in assuring long life of oven door linings. Certainly loss of carbon buildup as noted through our past experiences would have spelled complete loss of all oven door linings within a matter of four to six weeks.

Many methods of handling coke ovens during work stoppages and periods of low operation were studied and none appeared to fully satisfy the requirements of these two batteries. Much consideration was given, however, to a method employed first by the United States Steel Corp. at its Clairton works. This method has met with such favor that many plants now use it as a matter of course.

The Clairton system, as it is commonly referred to, is a pressurizing system whereby the pushing and charging of ovens discontinues until gas volume and pressure drops to about 0.23-in. water gage at the collecting mains with primary cooler inlet valves closed. At this time pushing and changing again continues at the rate of approximately one oven for each 30 ovens in a given battery per day. This is a coking cycle of about 720 hr and permits an approximate back pressure of 0.23 to 0.27 in. to be held at the collecting main, thus creating a non-oxidizing atmosphere in the oven chambers at all times. Excess gas from freshly charged ovens is merely bled off at spooning holes as required.

Underfiring of the ovens is accomplished with natural gas, being introduced through the cleaned gas booster system counterflow when normal flow of coke-oven gas diminishes to pressures below requirements of underfiring gas. The natural gas pressurizes all gas handling equipment throughout the by-product plant to the primary coolers.

It is felt a more detailed description of the Clairton system of pressurization is not necessary since literature covering this system is probably available.

This system is advantageous where many batteries are grouped, allowing use of existing crews on fully operating batteries to move over and fulfill the duties on the banked batteries. Also with many batteries pressurized, an entire operating crew can be assigned to this responsibility. In considering the one half mile separation between the two operating and two non-operating batteries at our plant, this advantage did not exist. Skeleton operating crews would have been retained to push, charge and screen an insignificant amount of coke. By-product plant forces and an infrequent coal preparation plant crew would have been required. Each oven as pushed would have required jamb patching in its entirely. The complete oven heating force would have been retained.

After fully considering all known methods and eliminating them one by one, a system of pressurization was agreed upon which was felt would give maximum protection at all times. We have not heard of its being applied at any other plant.

Of primary importance, for adequate protection or retention of the fine growth of carbon present in the two batteries to be banked, was the matter of maintaining a gaseous non-oxidizing atmosphere within the oven chamber at all times and at a pressure either equal to or slightly greater than the pressure in the heating flues. With this in mind it was felt that the oven chambers would be more uniformly pressurized empty than with coke in the chambers. It was also intended to keep the temperatures in the heating flues at a minimum of 1600 F at the ends, with the hope that in doing so maximum temperature in the center flues would be of the order of 1800 F. This being accomplished, the temperature in the oven chambers proper should level out quite uniformly, end to end at about 1650 to 1700 F, well above the ignition temperature of coke-oven gas. It was felt that this certainly could be accomplished without difficulties, and there was no apprehension of explosive mixtures of air and gas in the system. As the plan called for introducing surplus coke-oven gas from the No. 2 plant into the suction system of the No. 1 plant, into collecting mains and through the gooseneck and uptake pipe directly into the oven chamber, gas would merely ignite with the air in the chamber until the oxygen was expended, then the oven would contain only a non-oxidizing atmosphere of coke-oven gas under pressure.

Consequently it was decided to push the ovens empty, thoroughly spray patch each jamb as well as vertical and step joint cracks, prevalent in all batteries of this

age. Doors, standpipes and charging lids also were to be sealed airtight. When this was accomplished, the surplus coke-oven gas from No. 2 coke plant would be introduced, countercurrent to normal gas flow, through the No. 1 by-product gas handling equipment, to pressurize suction, crossover and collecting mains as well as oven chambers.

In preparation for the shutdown the following items were necessary:

1. Assure sufficient inventory of refractory spray mix for jamb and oven chamber patching. In completely eliminating gas loss through badly leaking oven doors due to warped doors and door frames, a prepared slurry mix had to be produced for spray application between the door frame and door structure.
2. Free and lubricate expansion joints on collecting mains to allow for contraction of the mains.
3. Free standpipe joints at oven top, also to allow for contraction of collecting mains.
4. Weld several minor collecting main leaks.
5. Free flushing liquor header ties, collecting main hand railings, and adjacent deck plating to allow for contraction.
6. Exercise and lubricate crossover and flushing liquor header valves.
7. Check and adjust, where necessary, pressure recorders and ratio controls on crossovers.
8. Prepare small steam bleeders for pitch traps to prevent freezing.
9. Install four $\frac{1}{8}$-in. tell-tale bleeders for ends of collecting mains.
10. Close suction seal drains on primary and secondary coolers.
11. Install 6-in. butterfly control valve and 15 ft section of 6-in. pipe with orifice, between by-pass lines on Nos. 1 and 2 exhausters.
12. Drill $\frac{1}{4}$-in. hole, tap and provide nipples, in four pusher side and four coke side oven doors for pressure measurements one ft off floor of oven.
13. Install metering lines from reversing room end of the two collecting mains to visual meters in the reversing room.
14. Install high pressure alarm at the reversing room.

When these items were completed, pushing and charging of ovens were discontinued at 11 pm, in preparation for the banking procedure to start at 7 am the following morning. At that time, pushing the ovens empty started.

As each oven was pushed, a 2-man crew on each the pusher and the coke side sprayed oven jambs and cracks with a prepared slurry mix using a spray patching gun. After spray patching, doors were replaced and the area between door proper and oven door frame was filled with slurry, again using a spray gun, with 2-man crews on both pusher and coke sides. Standpipe and charging lids were hand sealed with slurry also, and when this was accomplished, the oven was pressurized from the collecting main. The gooseneck spray as well as steam supply for decarbonizing and charging the oven was shut off at the headers. The Corliss valve was opened to drain the gooseneck seal. The ovens were pushed at approximately 20-min intervals throughout the pushout, or a total of 49 hr-18 min from first to final oven. This time was considerably longer than the before-hand estimated time. However, the severe, near zero temperatures with strong southwest winds which prevailed almost without let up during the 2-day period, added immeasurably to the time, particularly on the coke side bench, where spray gun valves would freeze even between pushes, causing constant delay. Small salamanders were an essential part of the equipment carried with the guns in an effort to minimize this delay. The severity of the weather also had an adverse effect on the patchermen. The door sealing crew fell far behind the oven chamber patching crew to the extent that approximately eight additional hr were needed to complete the sealing operation after pushing the final oven.

Approximately 20 hr following the final charge, gas make appeared to be quite low and it was decided to take the by-product exhauster out of service to pressurize the suction mains, primary and secondary gas coolers. The exhauster discharge valve was slowly closed over a period of 15 min, with the machine continuing to operate with the 12-in. exhauster by-pass valve open about six in. As the discharge valve was being closed, the suction system of course developed pressure. In order to maintain a maximum 0.35-in. pressure on collecting mains, several standpipe lids at batteries were raised to bleed off excess pressure to atmosphere. When the exhauster discharge valve was fully closed, the exhauster was stopped and the by-pass valve closed.

As gas make at ovens continued to diminish, standpipe lids were closed one by one to maintain the beforehand established 0.35-in. pressure at collecting mains. When all lids were finally closed and this pressure began to drop below the desired 0.35-in. pressure No. 2 plant surplus coke-oven gas was introduced to the system through the 6-in. butterfly control valve inserted in the 6-in. diameter, 15-ft long by-pass line containing an orifice for metering gas used for pressurizing. This line extends from the discharge line of No. 1 exhauster to the inlet line of the No. 2 exhauster. The ratio controlled butterfly valve was adjusted to hold 0.08-in. pressure at the exhauster, this being the pressure necessary to assure 0.31 to 0.35-in. pressure at the collecting mains.

Following pushing and pressurizing the final oven, all suction main crossover valves remained open permitting equal pressures in all sections of collecting mains. All by-product gas handling equipment remained fully pressurized.

Underfire reversals at batteries remained normal with gas burning 30 min and gas off 30 min.

Two meters were positioned in the reversing room to indicate pressures in end of each collecting main. One of the meters was used by the heater in reading and recording pressures on the eight oven doors twice per shift. An alarm was positioned at reversing room to sound if pressure in the collecting main increased to 0.59 in., and was audible over the entire plant.

The need for this high pressure alarm was necessary because surplus coke-oven gas to the steel plant is controlled to approximately 23-in. minumum pressure at the exhauster house. In the event of a sudden curtailment of gas use at the steel plant, a back pressure to the extent of approximately 28-in., sufficient to open the coke-oven gas bleeder might develop and some apprehension as to leakage past the 6-in. pressurizing con-

trol butterfly was felt. However, during the time the coke plant was idle, the steel-plant gas load was constant, and no periods of back pressure developed that could not be properly controlled with the 6-in. butterfly control valve.

Flushing liquor headers were drained. Steam headers on the battery top remained pressurized and were bled at ends.

The four $\frac{1}{8}$-in. tell-tale pipes on both ends of each collecting main were ignited to indicate pressurization while the heater was reading temperatures or inspecting flues. These tell-tale pipes were also visible from the far reaches of the plant.

After the banking of these two batteries was complete and a leveling off period reached, pressures were as follows:

At by-product by-pass control valve, 0.04 to 0.06 in.
At collecting mains, 0.29 to 0.31 in.
At reversing room, 0.10 to 0.11 in.
At oven one ft above floor, 0.06 to 0.08 in.
Average flue temperatures were 1780 to 1800 F.
Average end-flue temperatures were 1600 to 1650 F.

A surprisingly uniform leakage in all end-flue gun brick helped keep end-flue temperatures above 1600 F which eliminated the necessity of dams in guns, often inserted in gun-flue batteries as an aid in deflecting excess gas to end flues. It is conservatively estimated here that approximately 50 per cent of heat input into the end flues is lost through heat radiation of door, frame, flashing and buckstay on empty batteries.

Gas use during early stages of pressurization totaled approximately 500,000 cu ft per day for the 146 ovens pressurized, or about 3400 cu ft per oven per day. Very gradually over the four and one half months of pressurization, and due only to a constant growth of carbon which covered all surfaces within the oven chamber, the gas use for pressurization diminished to approximately 1350 cu ft per oven per day.

Gas use for underfiring the two batteries totaled approximately 2,500,000 cu ft per day. Stack draft was held at 0.2 to 0.21 in. which gave approximately 0.08 to 0.10-in. pressure at the horizontal flue. Combustion was held heavy with slight deficiency of air.

While the No. 1 plant was banked two patchermen and one heater helper were retained for the first two weeks. After the first two weeks the entire scheduled plant force amounted to one heater on each of the three turns. The heaters then performed miscellaneous patching as required, read and checked flues and observed and recorded pressurization data. One supervisor was also present on each of the three turns. His duties amounted to observing the idle by-product plant, coal handling, the mill gas booster station and frequent contact with the heater.

During the month of April, it became necessary to also bank the No. 2 coke plant for four weeks. All coke production was stopped at this time. As the banking of the No. 2 plant was not to exceed four weeks, the decision was made to hold the coke in the ovens during this period rather than push the ovens empty. These batteries were in excellent condition, comparatively new and with no door leakage. They were pressurized in similar fashion to the No. 1 plant. Underfire gas use with coke left in the chambers was somewhat less than empty ovens, or approximately 1,650,000 cu ft per day for the 148 ovens at this plant. However, pressurizing gas was considerably more due to gas leakage from the roofs of oven chambers into flues, two brick courses down from the oven top. Pointing of flue brick joints prior to pressurizing would have prevented this excessive gas use. Pressurizing gas averaged about 4000 cu ft per oven per day throughout the 4-week period.

At the end of the 4-week period these ovens pushed without incident. Other than being oversize necessitating crushing, the coke appeared to be quite normal with good average physical strength and showing no ash.

During the 4-week period of complete shutdown of both plants, per-air-mixed natural gas having a value of approximately 800 Btu replaced coke-oven gas. The No. 1 plant having been previously pressurized with coke gas showed no change when the natural gas was introduced into the system.

The use of 800-Btu pre-air-mixed natural gas was not a disadvantage as no underfiring combustion air settings need be changed. One distinct advantage in this particular case developed, as one of the 1,500,000-cu ft dry seal, piston type blast furnace gas holders was converted to a natural gas holder when generation of coke-oven gas ceased. This permitted a near straight line plant wide pressure of approximately 13-in. water gage. A minor adjustment daily or even less frequently on a 14-in. gate valve kept the holder pressure constantly in good range.

A brief look at the results of the method of pressurization described and applied to the No. 1 plant is indicated. Shortly after banking the batteries, within five days, curiosity could not be further restrained, so several goosenecks were hand sealed by inserting a water hose into a plug on top of the goosenecks and filling the saucers. The ovens were dampered off cautiously, in a normal fashion in order to inspect the oven chambers from the charging holes. In pulling the charging hole lids, a moment's wait was necessary for the unburned gas to be consumed by the air circulating down through the charging holes and up through the standpipes. When the gas was dissipated, the coking chambers appeared to be in excellent condition, having lost no carbon but showing the effect of methane cracking with minute deposits of sooty carbonaceous material clinging to the oven walls throughout the entire oven chamber but somewhat more prominent in the area closest to the standpipe which admits the incoming pressurizing gas. During the approximately four and one half months the ovens were banked, periodical inspection showed a very gradual increase of this carbon until practically the entire chamber contained a coating from $\frac{1}{8}$ to $\frac{1}{4}$-in. thick, including the oven doors. In addition to this rather thin coating of sheetlike carbon, an accumulation of soft sooty material up to 3-in. thick covered much of the surface of the oven chamber. Continual decrease of gas necessary for pressurization, as mentioned earlier, reflected this carbon growth. Every joint and crevice was being systematically sealed with carbon. While watching this progress, the opinion was formed that no treatment short of normal coking practice could be more beneficial to the ovens. These opinions were fairly well substantiated when we placed the No. 1 battery in operation after being empty nearly four and one half months.

On starting up, the doors were removed and the ram was run through each oven to remove about two in. of crusty carbon covering the floors. Patchermen were available to hand patch any jamb cracks evident, but little work was necessary. The doors were replaced and the ovens charged. When the ovens were first pushed, no evidence whatsoever could be found to indicate that they had ever been out of service. Floors were glassy smooth, jambs were extremely tight, all previously mentioned cracks and joints well patched prior to pressurizing were fully carboned and the chimney on charging showed no evidence whatsoever of fume or gas leakage. Until the battery was given over two months later to the contractor for some before mentioned needed repairs, not one oven-door lining brick had been lost.

Somewhat in contrast to this, batteries No. 3 and 4 pressurized with coke in the ovens for only four weeks appeared to grow a small skin of carbon on liner brick just above the coal line, but along the walls adjacent, the mass and in particular the bottom of the oven, carbon seemed to have become somewhat less.

To look at some of the advantages of pressurization for a moment, other than in actual protection to oven brickwork; during work stoppages and periods of recession, labor costs can be held to a minimum. Coke stocking with considerable degradation to coke, and always extremely costly can be eliminated. In our particular situation, coke stocking must always be on leased property over an independent railroad with switching charges in both directions. Coal purchases can be stopped. Long coking time cokes, often greatly inferior to normal coke, do not have to be produced. Bleeding of raw gas to the atmosphere can be minimized if not eliminated, when placing batteries in and out of service.

In considering the wisdom of pressurizing or not pressurizing, with coke in the ovens or ovens empty, opinions will vary greatly. It is a decision for each operator and his management to decide. No one knows the capabilities of a given battery of coke ovens better than the man who lives with it. Who can deny that no two batteries have the exact same characteristics even though they were built together from identical prints, with the same materials and virtually the same hands.

If consideration is being given to the possibility of pressurizing, several items would seem to be of importance, namely:

1. Completely tight jambs and doors.
2. Ability to properly heat end flues.
3. Proper control of regenerator temperatures.
4. As near neutral pressure differential between oven chamber and heating flues as possible with no excess oxygen on combustion to burn gas leakage either into flues from oven chamber or vice versa. In several cases of pressurization, fluxed silica liners and/or flue damage has resulted.
5. Assured, preferably controlled supply of gas.

It was mentioned that the two batteries at the No. 1 plant were approaching the time when some repairs would be necessary.

Approximately 18 months ago a comprehensive detailed study of the batteries was made, and a lengthy report was submitted to management outlining recommended repairs.

A few of the recommendations were as follows:

1. Resurface the battery tops. The transverse tie rods originally were inserted in the brickwork flush with the battery top. Over the years they have lifted, creating a hazardous condition to oven workman as well as creating a housekeeping problem. No crown was provided for these batteries originally, and water accumulation was troublesome.
2. Replace Corliss valves as gooseneck seals, with pullman type saucer dampers. The Corliss valves with a small opening were easily plugged and had to be continuously punched through to prevent sealing freshly charged ovens from the main. Also corrosion had caused approximately half the goosenecks to leak. This was a hazardous problem when an oven was taken off the main for pushing.
3. Remove and straighten buckstays. This was done by V notching the stay in several places, pressing the stay to a plane, then rewelding the notches.
4. Replace corroded and warped coke-side door frames with new frames.
5. Dismantle, straighten structure, and rebuild all oven doors.
6. Repair coke-side end flues by demolition of old brickwork and rebuilding flues with new silica brick. This repair extended to the second flue in many cases and included alteration to the gun brick.
7. Replace pusher-side frames and thoroughly point all brickwork on pusher side.
8. Grout oven floors.

Other repairs and corrections were included. Actually a project of this nature is a story in itself.

The management of Great Lakes Steel Corp., although faced with a continuing decline in production, the end of which was nowhere in sight, appropriated sufficient funds to permit repair of these two batteries of coke ovens thereby assuring uninterrupted, quality coke supply for many years to come.

The No. 2 battery was taken off pressurization May 8, 1958, and given to the contractors for repairs. This battery was placed in operation again October 8, 1958. The No. 1 battery was pushed empty August 15, 1958, and placed back in operation January 9, 1959.

Discussion

PRESENTED BY

W. J. REILLY, General Manager, Steel Mill Div., Ford Motor Co., Detroit, Mich. (now deceased)

A. D. SHATTUCK, Superintendent, Coke Oven Plant, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

W. J. Reilly: Did you mention the gas input to these ovens at the start? How did that stand up through the life of this pressurizing period? What was your make-up gas?

A. D. Shattuck: When we first started pressurizing we were using about 3400 cu ft per day per oven and at the end of the four and a half month period, that had diminished to approximately 1350 cu ft per day per oven.

W. J. Reilly: Was this due to carbon build-up?

A. D. Shattuck: The build-up of carbon sealed all cracks and joints. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, April 24, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"A-C Crane Control," by A. H. Myles, Chief Engineer, Electric Controller and Manufacturing Co., Div. of Square D Co., Cleveland, Ohio

Redmont Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, April 11, 1961—Inspection Trip 2:30 P.M., Social Hour 5:00 P.M., Dinner 6:00 P.M., Meeting 8:00 P.M.

Inspection Trip 2:30 P.M.—Atlas Steels Ltd., Welland, Ontario, Canada

"Planetary Mill Operations at Atlas Steels," by D. Roland, Manager, Cold Processing Dept., and H. Barrick, Superintendent, Strip and Tube Dept., Atlas Steels Ltd., Welland, Ontario, Canada.

Dinner and Meeting, Prudhommes Garden Centre Hotel, Vineland, Ont., Canada

CANTON SECTION

Monday, April 17, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Buck Passing Discussion on Surface Quality of Steel by Rolling Mill, Inspection and Conditioning Personnel."

Mergus Restaurant, Canton, Ohio

CHICAGO SECTION

Tuesday, April 4, 1961—Dinner 6:15 P.M., Meeting 7:45 P.M.

"Modernize Mills or Replace Them?" by T. F. Plimpton, Assistant to Vice President, Inland Steel Co., East Chicago, Ind.

Tiebel's Restaurant, Schererville, Ind.

CLEVELAND SECTION

Tuesday, April 18, 1961

Ladies Night

Movie: **"Veins of Steel,"** presented by Helmut Borger, Vice President, Mannesmann-Meer, Inc., Youngstown, Ohio

Travelog: **'Off the Beaten Path in Switzerland,"** by W. W. Spanagel, Special Representative, Reliance Electric and Engineering Co., Cleveland, Ohio

Cleveland Engineering & Scientific Center, 3100 Chester Avenue, Cleveland, Ohio

COLORADO SECTION

Tuesday, April 18, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Coke Plant Operations," by C. K. Pearson, Assistant Plant Foreman, Chemical Section, Coke Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

Tuesday, April 11, 1961—Dinner 6:30 P.M., Meeting 8:00 P.M.

Great Lakes Steel Corp. Night

"High Strength Steel and the Changing Future"

"Research and Product Development," by C. L. Altenburger, Technical Assistant to the President, in Charge of Product Development and Research, Great Lakes Steel Corp., Div. of National Steel Corp., Detroit, Mich.

"Engineering and Design," by P. C. Vetter, Vice President, Engineering, Great Lakes Steel Corp., Div. of National Steel Corp., Detroit, Mich.

"Practical Applications in the Steel Plant," by Steven T. Kraft, Assistant General Plant Superintendent, Great Lakes Steel Corp., Div. of National Steel Corp., Detroit, Mich.

Dearborn Inn, Dearborn, Mich.

LOS ANGELES SECTION

Monday, April 10, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"What's New in Steel Mill Regulation and Control Systems," by Lavar C. Holman, Application Engineer, General Electric Co., Los Angeles, Calif.

Michael's Restaurant, 6309 E. Washington, Los Angeles, Calif.

PHILADELPHIA SECTION

Saturday, April 8, 1961—Dinner 6:00 P.M., Meeting 7:00 P.M.

"Operation of a Multiple Fuel High Pressure Boiler in an Integrated Steel Plant," by John W. Leming, Jr., Assistant Fuel Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Grace Mine Development," by S. J. Shale, Manager, Bethlehem Cornwall Corp., Cornwall, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, April 10, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"The Engineering-Purchasing Relationship," by W. W. Crawford, Director of Purchases, United States Steel Corp., Pittsburgh, Pa.

University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

No April Meeting.

SAN FRANCISCO SECTION

No April Meeting.

UTAH SECTION

Monday, April 10, 1961—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"Automation and Process Control in Soviet Iron and Steel Industry," by W. E. Miller, Manager, and R. M. Sills, Application Engineer, Metal Rolling & Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

Grandview Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, April 17, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Hot Blast Cupola," by E. S. Harman, President, E. S. Harman Corp., Chicago, Ill.

Mahoning Country Club, Girard, Ohio

Fundidora de Fierro y Acero de Monterrey, Mexico Reports on Their New Combination Merchant Bar and Rod Mill

by A. FERNANDEZ,
General Superintendent of Rolling Mills,
and B. R. WIBLE,
Consulting Engineer,
Cia. Fundidora de Fierro y Acero de Monterrey, S.A.,
Monterrey, N. L., Mexico

The necessity of satisfying a growing sales market prompted the installation of a combination bar and rod mill capable of producing 160 sizes and shapes.

COMPANIA Fundidora de Fiero y Acero de Monterrey is the oldest steel producer south of the Rio Grande river—not only in Central but also South America; its main producing plants are located in Monterrey, Mexico, 140 miles south of Laredo, Texas. It started operation in 1903 with a rated capacity of 90,000 tons per year of finished structural and merchant products, and is now undergoing an expansion to 500,000 net tons per year with the addition of a blast furnace materials handling system, a new open hearth shop, new soaking pits, a new blooming slabbing mill, a separate billet mill and a flat rolled products plant. Further expansion to 1,100,000 tons is in the immediate future.

This paper covers the design, installation and initial operation of the completed first step expansion—the new combination merchant bar and rod mill which was conceived as necessary in 1953 and placed in operation the spring of 1956.

In the spring of 1953 management recognized that further expenditures trying to improve the operations of the old merchant mills to satisfy the growing sales market would be uneconomical. A decision was made to replace the 18-in. shape finishing mill and the two duplicate 12-in. bar mills, with one modern combination merchant bar and rod mill.

Inquiries to the Export Import Bank of Washington, D. C., requesting assistance in the form of a loan covering approximately one half the total investment were made and approved, when substantiated by engineering studies presented on the behalf of Fundidora by qualified consulting engineering companies from the U. S.

In general, the mill was to produce all the products of the three existing merchant mills, $\frac{3}{8}$-in. diameter rod to 3-in. beam on a jobbing mill basis, plus new rod and skelp sections. It was to relieve the 28-in. mill of the uneconomic 4-in. beams and channels, and was to reduce manpower and increase tonnage to 120,000 tons per year in a 3-shift operation.

A decision was made to give the contract to supply both mechanical and electrical units and the over-all responsibility to one mill builder in August, 1953, based on this layout and other considerations.

BUILDINGS

Coordinated efforts of the plant personnel and the mill builder established the necessary main mill and auxiliary building location and service requirements. Fundidora plant engineering modified the antiquated feed and discharge service systems to supply the required utilities; water, gas, electrical power and new railway lines to the mill area.

They also converted the mill builder's machinery bolt plans into excavation and foundation drawings complete with all details, and directly supervised the local labor through the excavation and construction of all equipment foundations. Main and auxiliary buildings were designed, sections rolled, steel fabricated and units erected by Fundidora personnel.

The billet yard (suitable for storing approximately 16,500 tons of 4 x 4 in., 6 x 6 in., 8 x 3 in. or 6 x 3-in. billets) is a 60 ft-0 in. x 400 ft-0 in. area served by a 19½-ton crane on an open crane runway.

The main mill building, 70 ft-0 in. x 1300 ft-0 in., is of fabricated steel with 44 ft-0 in. height from floor level to bottom chord and 33 ft-0 in. to the crane rail. It has an overhanging step roof which is pleasing to the eye, easy to construct, low in cost and provides a maximum of natural light and coolness for the local weather conditions. The roofing and siding are corrugated sheeting with the bottom panels of the building open to provide a natural draft to carry the mill heat up through the step roof. This building is served by two cranes each with 19½-ton capacity.

The three motor rooms are constructed of concrete block, brick and glass block, resting on heavily reinforced concrete walls and footers; all are completely enclosed and each has a filtered air system developing a positive pressure to eliminate infiltration of dust and dirt. Only the main motor room has an overhead traveling crane. Both mill and motor rooms are color harmonized to provide high operator morale.

Along the north side of the main building is a 30 x 600-ft "lean to" building covering the guide shop, mechanical and electrical storage areas, washrooms, offices, rod pouring reels and conveyors. The "lean to" has no overhead crane service.

At right angles to the west end of the main mill building is a 60 x 200-ft finished product storage and shipping building served by an 8¼-ton crane, with loading facilities for both railway and truck shipping. Provisions have been made to add a duplicate storage and shipping building when the need develops, running parallel to the first.

Due to the coordinated efforts of all involved little time was wasted. All suppliers shipments were made before necessary dates for erection. The project scheduling was limited by the local labor facilities which were more than adequate for excavation and foundation work, but were especially limited in assembly and erection of mechanical and electrical machinery.

The mill was not erected on a crash program basis, but actual ground breaking was started in March 8, 1954, and the initial trial rolling of ⅜-in. diameter rod was made February 2, 1956, or 23 months later.

MILL LAYOUT

Due to the type of market this mill serves, the layout had to be and is extremely flexible, sacrificing on some individual products to cover the extreme wide range of products.

The mill layout permits the mill to operate as a double strand semi-continuous rod mill, a single strand medium to heavy bar mill, or a cross country shape mill depending on the product requirements, see Figure 1.

With a product mix of 160 sizes and shapes, ranging from No. 5 rod to 3-in. diameter rounds and up to 4-in. beams and channels, and with the sales potentials favoring the lightest weight products; it was obvious, to be successful, that the mill had to be designed to produce the lighter weight products at reasonable high rates per hr. Otherwise, there would be no time available for

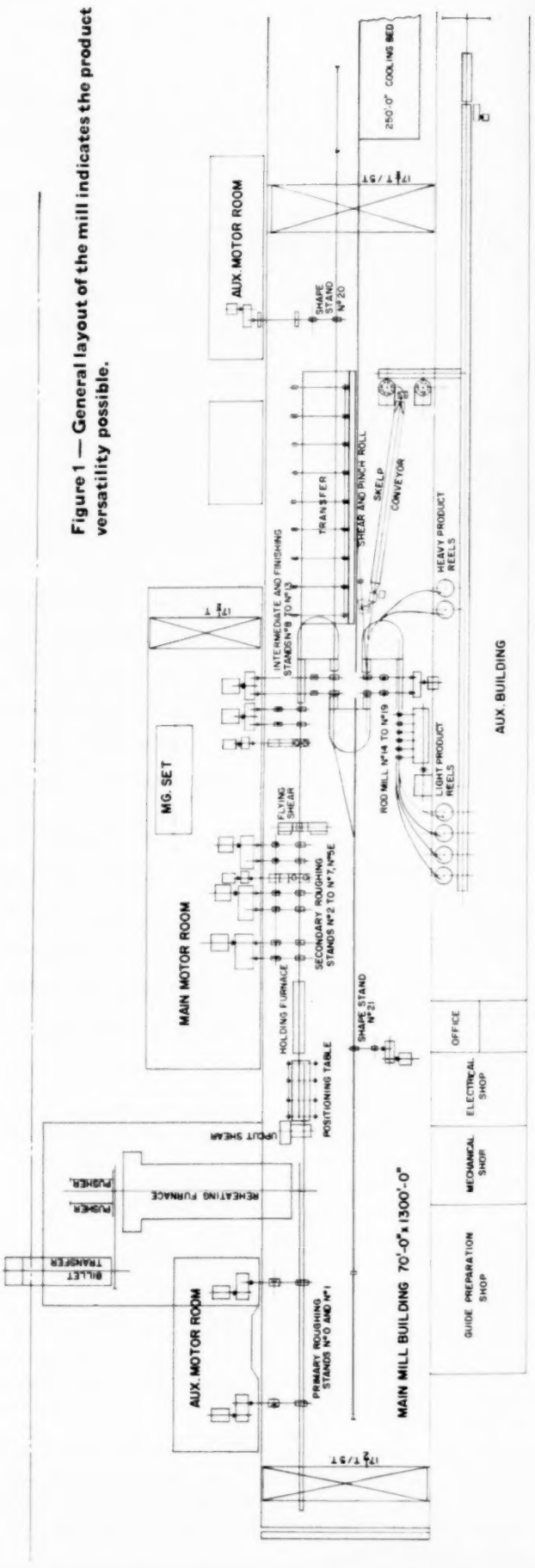


Figure 1 — General layout of the mill indicates the product versatility possible.

the low tonnage products and their many mill changeovers.

This changeover downtime problem was greatly reduced by providing six outlets for finished products: which, when properly scheduled in minor to major size product sequence, permit the setup of unused next product stands without interference with the product runs. In some instances 50 per cent of the changeover stands can be completely modified for the next section before mill production is halted.

To accomplish these purposes the mill was designed with a primary roughing group, a continuous secondary roughing group, a looping intermediate and finishing group, a rod finishing train and two solitary stands for shape products. The mill is laid out to use stands No. 0 to 19 when used as a double strand semi-continuous rod mill producing rods No. 5 to $^{11}/_{32}$-in. diameter into the light weight product reels or outlet number No. 1.

It uses stands No. 0 to 13 when operating as single strand semi-continuous light to medium bar or skelp mill. Under these conditions it produces $^{3}/_{8}$ to 1-in. rounds, squares and concrete bar into the heavy weight product reels or outlet No. 2. It also produces in this "setup" $^{3}/_{8}$ to $1^{1}/_{8}$-in. diameter rounds, equivalent squares, hexagonals, octagons, small angles, which can be repeated in mechanical repeaters, up to $1^{1}/_{4}$ x $1^{1}/_{4}$-in. leg length, and small flats up to $1^{1}/_{2}$ x $^{3}/_{8}$-in. which pass directly through the flying shear to the cooling bed or outlet No. 4. Or it produces skelp, for electric weld pipe, up to 8 in. in width onto the vibrating table, or outlet No. 3.

Stands No. 0 to 9 are used when operating as a heavy products continuous bar mill producing $1^{3}/_{4}$ to 3-in. diameter plain and alloy rounds, plain carbon squares, flats 4 x $^{1}/_{4}$ in. to 8 x 1 in. directly to the cooling bed via the run-out table transfer or outlet No. 5.

The mill uses stands No. 0 to 11A, dropping the unnecessary stands of the duo units in the continuous secondary rougher, plus stands No. 20 and 21 when operating as a cross country shape mill, producing $1^{1}/_{2}$ x $1^{1}/_{2}$-in. to 3 x 3-in. angles, 3 and 4-in. beams, 3 and 4-in. channels; 16 to 30-lb mine rails, splice bar for 56 to 112-lb rails; $1^{1}/_{4}$ to $1^{1}/_{2}$-in. plain rounds, squares and hexagonals; and flats from $1^{1}/_{2}$ x $^{1}/_{4}$ in. to 4 x 1 in. under this setup. These products are produced from either a 12 or 14-in. finishing stand, depending on their need, delivering directly to the cooling bed via the run-in table or outlet No. 6. In all we use 22 horizontal and two vertical mills in this combination mill layout.

MECHANICAL SUPPLY

The primary rougher mill area consists of a ratchet type billet receiving bed, furnace approach tables and furnace pushers, controlled by one operator, see Figure 2, together with the billet reheating furnace, Figure 3, and two 18 x 60-in. 3-high mills arranged in tandem. These mills are of simple design with plain fabric bearings.

High level tables receive the billet from the furnace and deliver it successively to the first two top passes, one in each 18-in. mill stand as formed between the top and middle rolls. Prior to entry into each pass the bar is manipulated through 90 degrees by mechanical devices controlled from the pulpit. Delivering out of the No. 2 pass onto a high level run-out table the bar is dumped, manipulated automatically and returned back on low level tables into the third and fourth passes formed between the bottom and middle rolls of each stand. At no time is any bar in more than one pass.

Figure 2 — One operator handles billet receiving, the furnace approach tables and the furnace pusher.

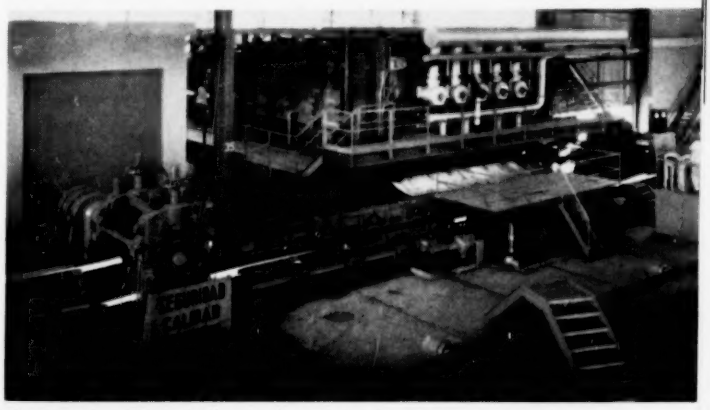


Figure 3 — The billet reheating furnace is capable of delivering 40 tons per hr to the primary mills.

This arrangement provides an extremely flexible, fast, high tonnage rougher driven by relatively cheap a-c motors with simple controls. All product requirements are covered with one common roll design. Each pass operates as a free bar; therefore, the drafting of each pass may be adjusted independently. Since they are preset 3-high mills, they provide accurate consistent bar stock with the minimum of effort for the continuous secondary roughing mills, see Figure 4.

Between the primary and secondary roughing mills there is the low level mill delivery table, the crop and divide up cut shear, the billet positioning table and the roller hearth holding furnace. In event of delay this furnace can store all billets being processed plus those being produced on the preceding 18-in. mills. This storage feature has been a big asset in holding scrap losses to a minimum during trial periods, see Figure 5.

The continuous secondary roughing mill group is composed of six continuous horizontal units of 16 x 44-in. mills with tapered roller bearings on straight necks and separate and thrust adjusting devices.

These stands are No. 2 through 7, and are driven by three double outlet gear reducing units. There is also one vertical edger No. 5E, which can be pulled out of line when not in use. Following stand No. 3, there is a hydraulic descaling system using 1000-psi water at the rate of 50 gpm. Following No. 7 stand there is now a new electrically operated flying shear (Figure 6) capable of shearing either crop ends or cobbling up to 1½ sq in. cross sectional area at speeds up to 650 fpm on either one or both lines simultaneously. Larger cross sections pass through the shear without cropping. Originally, an air-operated shear was installed in this position but the mill builder replaced it with the present electric motor driven units which have operated most satisfactorily.

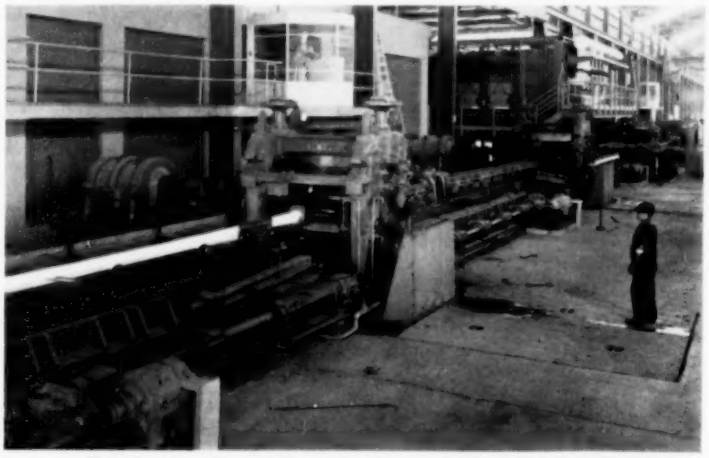


Figure 4 — Two 3-high mills provide consistent bar stock for the secondary roughing mills.

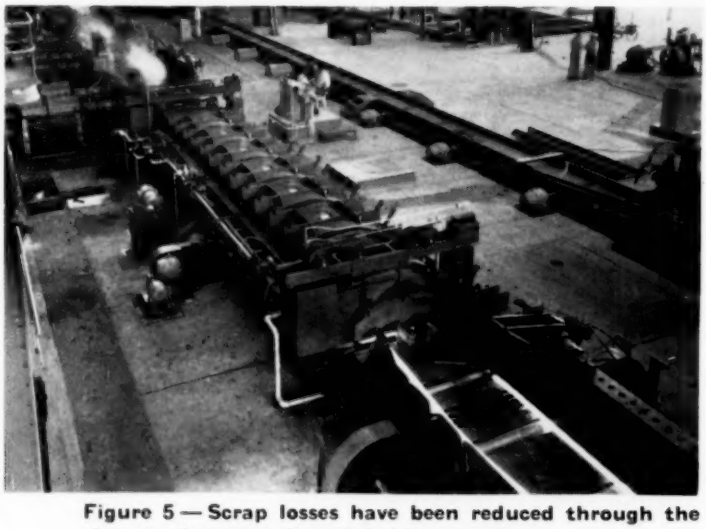
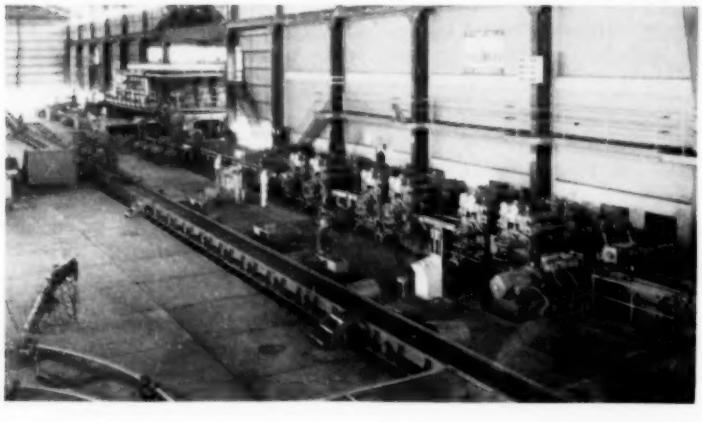


Figure 5 — Scrap losses have been reduced through the the use of a rotary hearth holding furnace.

Figure 6 — A newly installed electrically-operated flying shear has removed a bottleneck caused by an air-operated shear.



Following the flying shear is the looping intermediate and finishing group composed of one independent vertical edger No. 7E and drive, and four horizontal 14 x 36-in. intermediate looping mill stands No. 8 to 11 with similar bearings and end thrust adjusting devices and driven through two double outlet gear reducers.

When operating as a rod mill these stands utilize the double line grooves in the permanently positioned repeaters. When operating as a cross country mill these stands working with stands No. 20 and 21 deliver and receive the bars from the transfer tables. Stand No. 11 can be positioned in line with the cooling bed run-in table as No. 11A, and finishes such large shapes as 4-in. beams, 3 x 3-in. angles, etc.

Stand No. 12 and 13 are two 12 x 24-in. 2-high mills with roller bearings on tapered necks and separate ball thrust units, driven through one double outlet gear reducer. The 12-in. mills are arranged to receive single or double line bars from No. 11 stand through a repeater and deliver same either to the cooling bed, to the skelp vibrator, to the heavy rod pouring reels, or into another repeater and hence to the rod mill train. Stand No. 13 also can be positioned in a No. 13A position giving us a 12-in. finishing mill directly in line with the cooling bed run-in table to produce intermediate to heavy shape and bar products as 2 or 2½-in. angles, 4-in. channels, etc., which cannot be repeated but which we prefer to finish on the 12-in. mill rolls. These mills can finish to the cooling bed at up to 2200 fpm, and to the heavy reels at up to 3000 fpm, see Figure 7.

The rod finishing mill train, No. 14 to 19 stands, consists of six 10½ x 18-in. mills on 3 ft-6 in. centers with similar bearing arrangements as the 12-in. mill, driven through a single spiral bevel gear drive and pinion stand unit, arranged for double line rolling of rods.

The only other two mills are 14 x 36-in. 3-high stands No. 20 and 21 for shape products, designed as simple mills with open fabric bearings, simple roll clamps for end thrust adjustment, etc. Some shape products require only the two passes on one stand, some require both stands, while 4-in. beams require four passes in stand No. 20 and two in No. 21. Since these semi-finished shapes are fairly plastic in their hot condition neither No. 20 or 21 have tilt tables, but rather simple flipper chutes on which the bar being rolled raises when delivering from the bottom passes and up which it is driven by the table rollers to enter the top passes. Back mill tables are positioned at a compromised height to prevent the angularity of entry into the top pass being a problem.

The reels for light weight products coil rods No. 5 to $^{11}/_{32}$-in. diameter from 2500 to 4500 fpm in bundle weights of 4000 lb.

The heavy rod reels coil products ⅜ to 1⅛-in. diameter in bundles from 450 to 800 lb at speeds from 1500 to 3000 fpm.

A pallet type slat conveyor, common to both reel groups with a secondary conveyor for separating the coils, an upender and the star receiver for loading the

ram type buggies complete the auxiliaries for rod production.

Bar products up to 1-in. diameter and shapes up to $1\frac{1}{4}$ x $1\frac{1}{4}$-in. angles deliver to the cooling bed in multiple lengths through a disk type shear which rotates through approximately 75 degrees for each cut. All products heavier than those listed require no additional auxiliary equipment other than tables or transfers already mentioned.

The cooling bed is a single sided notched or plain bar "turn over" walking beam type 250 ft-0 in. long x 24 ft-6 in. wide. It is divided into two sections which can operate in unison or independent of each other.

The cooling bed run-out tables, shear approach table, saw and shear were old existing items from the dismantled mills. On heavy flats, large rounds, large angles and channels, the shearing and sawing facilities limit the mill production. A modification providing more capacity will be made to these units.

ELECTRICAL EQUIPMENT

The electrical supply of the combination mill demanded extensive studies be made of the roll design requirements of all products. Using these data sheets, the best possible selection of motors and speed ranges were made for the individual requirements.

Accurate dependable speed regulation per motor was required to produce finished products free of excessive push and pull through the continuous mills. Main motors with improved low impact speed drop characteristics were selected to operate with double outlet gear drives throughout the mill. This arrangement reduces maximum impact loading on single strand operation by one half, and on double strand products only one quarter full load can be applied at any one instant. On heavy shape product schedules where many heavy loads may occur due to uneven or excessive drafting, only one stand of the double unit is often used, thereby providing the full rated hp of the motor for a single pass.

The 600-volt d-c power for the six main motors totaling 4600 hp is supplied from the main motor-generator set consisting of three 1500-kw, 514-rpm, 600-volt generators driven by one 6400-hp, 4000-volt, 3-phase, 60-cycle synchronous motor. The three generators are connected in parallel to a common bus and are excited from a single rotating voltage regulator.

Group speed control is determined by armature voltage. Individual stand adjustment of motor speed is obtained by changing the motor field strength of each motor by means of coarse and vernier rheostats located in the central pulpit, see Figure 8. In order to obtain fast speed of response and to help maintain speed matching between stands a rotating speed regulator is also used in the motor field circuits for each main motor.

The 4000-volt, 3-phase, 60-cycle primary a-c power is supplied direct from the existing Fundidora power plant. The 250-volt, d-c auxiliary power is supplied from existing generators, one 1000-kw and three 300-kw located nearby. The 440-a-c power is also obtained from an existing 750-kva substation.

The switchgear and control panels for the a-c primary roughing mill motors are located in their own

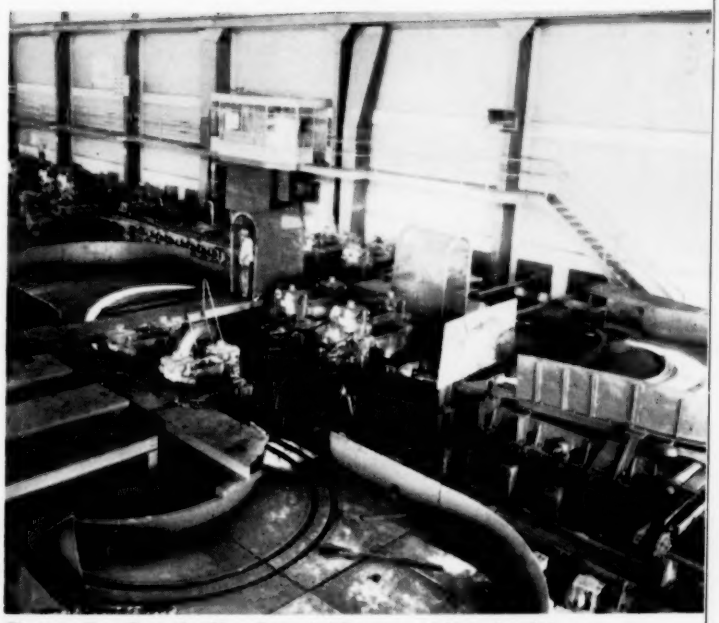


Figure 7 — Stands No. 8 and 13 are equipped with permanently positioned repeaters.

separate motor room, while the a-c motors driving the stands for shape products are controlled one from the main motor room and one from the cooling bed motor room.

The main motor room is 50 x 200 ft, on the main floor of which is located the five motors and the double outlet drives for stands No. 2 through 11, the edger drives and motors for No. 5E and 7E, the switchgear and control panels for the motor serving stand No. 21, the main motor-generator set, the exciter motor-generator sets, the instrument, exciter and regulator panels, the battery sets and certain auxiliary control and lubrication panels, see Figure 9.

The basement contains the motor and generator line panels, motor-operated rheostats and the main ventilating fans. Oil type air filters and intake fans are

Figure 8 — Speed matching for the secondary roughing, intermediate and rod mill stands is controlled from the main pulpit.

Figure 9 — The main motor room is completely enclosed and is ventilated by a positive pressure air system to prevent dirt infiltration.

mounted on the roof of each motor room. The main ventilating fans located in the basement pull the filtered air from the main floor area down through the mill motors and the motor-generator set, and discharge to the outside.

Motors driving stands No. 12 and 13, 14 to 19 and 21 are located in the mill area and are arranged for updraft ventilation. The forced air supply for these motors comes through duct work from the main motor room. Certain auxiliary motors also have provisions for cooling air circulation.

The cooling bed motor room contains the switchgear and motor for stand No. 20, the control panels and motor-generator set for the variable voltage demands of the auxiliary motors in that area, the d-c constant potential control panels and the a-c motor control center.

In addition to the main drive motors, there are 43 230-volt, d-c motors ranging in size from 7½ to 100 hp, and 58 industrial type d-c motors used mainly as individual table roller drives with ratings varying from 1.5 to 4 hp depending on their uses.

Also there are 23 440-volt, a-c motors from one to 60 hp driving hydraulic systems, descaling pumps, oil lubrication pumps, etc.

In all the only difficulty of major importance with the electrical supply has been the four 75-hp motors serving the light rod production reels, which when operating at weakened field have not had the response necessary for consistent No. 5 rod production. The modifications necessary are under consideration by the mill builder.

OPERATIONS

The mill started operating by producing ⅜-in. diameter rod into the heavy reels, single strand, on February 2, 1956.

Most mill personnel were selected from within our own organization after many meetings with union officials. Those men from the old mills with the best qualifications and work habits, who desired to work on the new installations were rehired to fill the positions to which they were best suited. No man selected as an operator had ever had an operating job before. None of the personnel had ever worked on continuous mills or cross country mills before and, only the rolling mill supervisor had even witnessed these types of units in operation. The company employed no outside technical help in the form of rollers, etc., to start these mills, but did have the assistance of the mill builder's staff while they were completing the cooling bed installations and during other critical periods.

This mill is operated with a total of 24 men per shift, irregardless of product being rolled. In addition to this, there is a 12-man maintenance crew including supervisors serving the mechanical, electrical, lubrication and guide preparation requirements. Despite these handicaps salable coils were produced on the first attempt and by the end of the month the plant was producing up to 485 coils or 89 tons per shift.

In the early months there were problems of teaching the fundamentals of continuous rolling to all the personnel, the setting of the guides and conical twisters, the mill speed and screw-down adjustments for each pass and product, to produce the proper sections and to correct looping or stretching of the bar between stands, the proper twist setting to permit the bars to operate in the repeaters the methods of removing cobbles quickly and safely, etc. Good housekeeping, so essential to safety and operator morale, was taught along with the rolling technique.

Of course, during this time all the mechanical and electrical units were being smoothed out, clearances that seemed perfect in machine shop testing often had to be modified after running for a day next to hot steel, some few bearings had to be relieved and an oil hydraulic system had to be increased. A pneumatic system was inadequate and had to have an additional compressor added, etc. These things are all normal to mill startups, but they represent delays.

In July production dropped because of the early trials with No. 5 rod at 4500 fpm. Good quality rod was produced well within tolerances, but in very low tonnages. The main trouble centered about the original air-operated flying shear and its inability to cut at the required speeds.

Very little trouble originated in the rod finishing train despite the high speeds. We operated with manual switching from reel to reel at this time and many times the overanxiety of the inexperienced coiler operator in switching before the coil was completed caused wrecks.

The light weight reels when operating at maximum speed for No. 5 rod production are in the upper speed range of the motors, and in this condition they respond very slowly and inaccurately to any rheostat command, often not returning within 20 rpm of the same preset value on the dials within the same time limit. Often we would roll 10, 20 or 30 coils successfully and then have a wreck or successive wrecks without touching the controls. Fluctuations of the 1500-hp rod mill motor could not be detected. After weeklong trials with very little progress, discouragement would creep in and we would switch over to the next product.

In October the first operation through the disk shears to the cooling bed of ¾-in. diameter concrete bar was tried.

For the first 11 months of operation we had produced

at an average rate of 2310 tons per month in single shift operation on the lightest weight, single strand products, which represented the lowest tonnage potentials. The best month was December in which 3174 net tons were produced. We had on three occasions exceeded the mill builders estimates of 100 per cent probable production on $\frac{3}{8}$-in. plain rounds into coils by producing in excess of 165 tons per shift.

So, within 11 months after start up, using December's rate of production, we were within approximately three and one third tons per hr of the rate which could have produced the expected 132,000 tons per year in three shift operation. So far operating as a bar mill, single strand, single shift considering start up conditions, it was most successful.

The first quarter of 1957 saw a ten-day trial at No. 5 rod, the addition of 4-in. wide flat products in various thicknesses between $\frac{1}{4}$ to 1 in. and with 19 mill changeovers involving two or more stand changes, we produced 7865 tons.

Starting the second quarter, we split the experienced men into two crews; had 34 mill changeovers in all, added 3, 4 and 5 in. and some 6-in. wide flats from $\frac{1}{4}$ to 1-in. thicknesses, plus ten sizes between 2 x $\frac{1}{4}$-in. and $2\frac{1}{2}$ x 1 in., a six-day trial with $3\frac{3}{16}$ x 0.100-in. skelp and the first trials with 4-in. channel. In all we produced a few tons short of 11,000 tons.

The third quarter saw 25 mill changeovers of different type products, new trials again for skelp and 4-in. channel, other new flat products up to 6 x $\frac{5}{8}$ in. to 1 in. and No. 5 rod. Following this No. 5 rod attempt a decision was made to supply $\frac{1}{4}$-in. diameter rod for all our customers and interplant uses until the flying shear and reels would be modified by the mill builder.

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When operating as a bar mill there was continuing good tonnage performance, as a double strand rod mill there was little or no success due to the problems existing with the pouring reel motor control and the shear. As a cross country mill so many new rolling techniques had to be learned by the personnel that we could not properly evaluate the mill.

Hard luck was encountered with each attempt at 4-in. channel. Working with a limited member of rolls, actually only one set finish turned per stand, we would just start producing when mill accidents, from one cause or another, would break a roll, and we would be forced into a complete changeover of the mill to the next product.

The first half of 1958 there were 53 changeovers in the mill which produced 24,200 tons. The products were as follows: $\frac{1}{4}$ and $\frac{3}{8}$-in. diameter rod, 18 sizes between $\frac{3}{8}$ and $1\frac{1}{4}$-in. diameter plain and corrugated bars to the cooling bed, flats 2, $2\frac{1}{2}$, 4, 5 and 6-in. widths by various gages between $\frac{1}{4}$ to $1\frac{1}{2}$-in. thick, angles 2 x 2 in. up to 3 x 3 in. in ten different weights, 4-in. channel and 3 and 4-in. beam trials.

The second half of 1958 started off with a 17-day vacation for all personnel. In the following five and one half months there were 49 complete changeovers and mill produced 23,705 tons.

The product mix was similar to the first half production with less angle and flat products. In October heavy accurate round stock was added to the product list in commercial and alloy grades. Most of the alloy bars were sawed to special lengths and used directly as rollers in ore crushing mills.

On "startup" of these heavy round the twisting mechanisms were inadequate for twisting the stock but with our flexibility we substituted a cross country method and produced it without further mill difficulty. Production rates on these large rounds were limited by the shearing and handling limitations off the cooling bed.

In November a high tensile strength concrete bar design was added in all sizes which increased changeover problems since it rolls slightly different and must finish on rolls with special identification marks.

On the best day December 13th, we rolled 403 tons per shift of $\frac{7}{8}$-in. diameter bar to the cooling bed or 51 tons per hr single strand, with several hours exceeding 57 tons, proving again the merchant bar potential of this mill.

In summary the yearly production of 1958 of approximately 48,400 tons was certainly not up to expectations; however, it was partially a reflection of the market conditions, wherein we had orders but always of products new to the mill. Proper sequence scheduling of products to be rolled on the mill was not possible due to the irregular sales demands, and the limited rolling into stock that we felt could be justified by the conditions. Even so, finished product stock pile rose appreciatively.

We had greatly improved the rod production, since the new flying shear had been installed during the July vacation period and with the first trials in August, we produced up to 110 tons per shift of $\frac{1}{4}$-in. diameter rod despite excessive delay hr per shift.

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The 1959 figures show 4-in. channel well under control, although there is still some unaccountable roll breakage. We just completed a 3300-ton campaign with consistent tonnage of 26 ton per hr on this product, $\frac{1}{4}$-in. diameter rod production has risen to 990 coils or 165 tons per shift. April, 1959, production exceeded 8800 tons per month.

SUMMARY

Through many people's coordinated effort, this combination mill and all its requirements have been designed, manufactured, installed and operated through its early years. This mill is adequate for all production requirements.

To our knowledge it covers the widest range of products ever attempted on a high speed modern mill. It has produced quality products with reasonably

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To our knowledge it covers the widest range of products ever attempted on a high speed modern mill. It has produced quality products with reasonably

high yield figures and has produced tonnage rates per producing hr according to the specifications. However, the daily production figures have been too low due to many hr lost in simple delays per shift not keeping the mill rolling, and many production hours being lost in changeovers through present scheduling practices. New incentive wage rates will increase interest in keeping the mill rolling.

Some people still lack training, but the accomplishments show the balance is not insurmountable. The housekeeping could be a model for any mill in any country, and the safety record on this mill is excellent. As pointed out the light weight product reels still require some modification to be considered satisfactory.

The mill has considerable more potential capacity than has been shown to date and when sales can be more selective, the personnel more experienced on its extremely wide range of products and with the ever excellent support of top management the mill will exceed every expectation.

Discussion

PRESENTED BY

L. KLISZAK, Instrument Foreman, Wickwire Spencer Steel Div., The Colorado Fuel and Iron Corp., Buffalo, N. Y.

B. R. WIBLE, Consulting Engineer, Cia. Fundidora de Fierro y Acero de Monterrey, S.A., Monterrey, N.L., Mexico

L. Kliszak: With the type of fuel and burner that you are using, how do you maintain uniformity in temperature in the holding furnaces, and do you have any difficulty with descaling following soaking of your bars for a time, over and above your normal time?

B. R. Wible: The holding furnace has automatic temperature controls which limit the variation of furnace temperature to within very close limits.

The entering billet is relatively equal in temperature throughout its length due to having the colder front and back ends sheared just before entry into the furnace.

The billet is constantly being oscillated back and forth on the furnace rollers; thereby not allowing any hot spot to develop from the side burner flames. The furnace is long enough so the billets may oscillate back and forth without approaching the end walls of same.

Since all incoming billets have the same time exposure following their discharge from the main reheating furnace, and the same rolling procedures followed on the 18-in. mills, very little variation exists between consecutive billets. However, the furnace is divided into three longitudinal sections by the internal guides and aprons, and if any billet should be delayed on the primary roughing tables in excess of normal flow rate, then that billet would be diverted into one of the unused sections until its heat would be re-established. Of course, this only would apply to billets slightly under the normal temperature, we would not attempt bringing up a really cold billet in this manner.

Our billets are normally in this furnace only several minutes during normal production runs and scale formation resulting is no problem; however, in case of mill breakdowns of several hours, the scale does build up on these billets and causes some difficulty with skidding in stands No. 2 and 3 but, for the most part, the scale falls off readily at the high pressure descaler position. To date we have not noticed any unusual scale build-up throughout the rest of the mill due to these held billets.

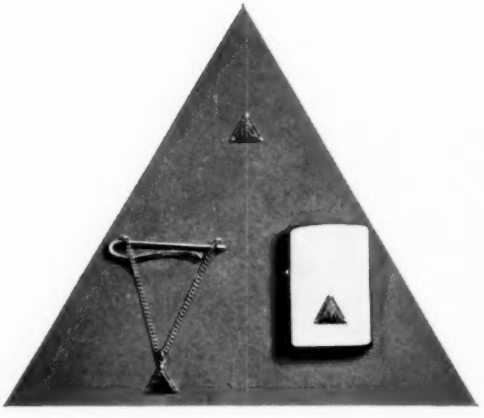
This furnace is maintained at approximately 2000 F, and oxidation occurs rather rapidly at that temperature. ▲

AISE Accessories Available To Members

• MEMBERSHIP PIN—complete with plastic case, finished in handsome blue and gold— $2.00

• TIE CLASP—gold plated tie bar and matching chain with AISE insignia, in attractive plastic case— $5.00

• LIGHTER—famous-make Zippo, in brush finish stainless case with embossed AISE insignia— $6.00



ASSOCIATION OF IRON AND STEEL ENGINEERS

1010 Empire Building **Pittsburgh 22, Pa.**

Night view of the St. Louis skyline as seen from the Mississippi River.

PROGRAM

AISE SPRING CONFERENCE

Auspices of Rolling Mill Committee

SHERATON-JEFFERSON HOTEL
ST. LOUIS, MO.

April 24, 25, 26, 1961

MONDAY, APRIL 24

8:30 am—REGISTRATION—
Mezzanine

9:00 am—ROLLING MILL SESSION—
Ivory Room

Chairmen: W. E. Dittrich, Superintendent No. 2 Mills Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

Wade F. Hoffman, Superintendent, Roll Dept., Aliquippa Works, Jones & Laughlin Steel Corp., Aliquippa, Pa.

"Photoelastic Study of Stress Distribution in Rolls," by L. MacNaughton, Roll Engineer, and A. A. Bradd, Coordinator of Rolls, Midvale-Heppenstall Co., Philadelphia, Pa.

"Influence of Wear on Pressure and Stress Distribution in Rolls of Four-High Mills," by Dr. Kin Nee Tong, Professor; M. Sadre and M. K. Chakko, Graduate Assistants, Department of Mechanical Engineering and J. V. Latorre, Research Engineer, Dept. of Chemical Engineering and Metallurgy, Syracuse University, Syracuse, N. Y.

"An Analysis of the Roll Flattening of a Double-Poured Roll," by Dr. Carl F. Zorowski, Assistant Professor, Mechanical Engineering and Dr. Alvin S. Weinstein, Assistant Professor, Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

9:00 am—ELECTRICAL SESSION—
Crystal Room

Chairmen: H. W. Dorset, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

J. F. Kostelac, Assistant Electrical Superintendent, Midland Plant, Crucible Steel Co. of America, Midland, Pa.

"Developments in Drive Systems and Gage Control for Reversing Cold Mills," by K. A. Petraske and R. M. Sills, Metal Rolling and Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

"The Application of a Non-Contacting Measurement System for Coating Weights on Continuous Galvanizing Lines," by James E. Reider, Area Manager, Industrial Nucleonics Corp., Columbus, Ohio

"Operational Results of Automatic Gage Control on a Hot Strip Mill," by Thomas Harmon, Jr., Chief Electrician, B. Huston, Assistant Superintendent, Hot Mill, Granite City Steel Co., Granite City, Ill., and R. M. Peeples, Supervisory Engineer, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

2:00 pm—ROLLING MILL SESSION— Ivory Room

Chairmen: F. G. Kredel, Chairman of Bar Mill Committee, Republic Steel Corp., Cleveland, Ohio

R. L. Dowell, Superintendent Cold Reduction, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

"Automatic Measurement of Bar and Structural Lengths," by C. H. Wexler, Associate Technologist, Instrument and Automatic Control Div., Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

"The Sendzimir Mill for Thin Tin Plate," by James F. Fox, Sales Manager and A. J. Beck, Chief Engineer, Rolling Mill Div., The Waterbury Farrel Foundry & Machine Co., Div. of Textron Inc., Waterbury, Conn.

"The Rolling of Ultra Thin Tin Plate," by Dr. Morris D. Stone, Manager, Development, United Engineering and Foundry Co., Pittsburgh, Pa.

2:00 pm—COMBUSTION SESSION— Crystal Room

Chairmen: William M. Bloom, Chief Fuel Engineer, General Engineering, Allegheny Ludlum Steel Corp., Pittsburgh, Pa.

Charles W. Dunn, Superintendent, Utilities Dept., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Four-Zone Reheating Furnaces and Pusher Controls," by William A. Greene, Assistant Superintendent, Plant No. 2 Mills, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"Construction and Maintenance of Regenerative Soaking Pits with Plastic Refractories," by F. E. Waterman, Division Superintendent—Primary Rolling Mills and W. H. Kirwan, Superintendent, 43-In. Blooming Mill, Youngstown District, United States Steel Corp., Youngstown, Ohio

"Simulating Thermal Response in Slab Reheating," by C. G. Bigelow, Vice President, Research, Selas Corp. of America, Dresher, Pa.

TUESDAY, APRIL 25

9:00 am—ROLLING MILL SESSION— Ivory Room

Chairmen: J. L. Dawson, Superintendent, Blooming, Hot Strip & Rolling Mills, Aliquippa Works, Jones & Laughlin Steel Corp., Aliquippa, Pa.

G. M. Esler, Superintendent, Blooming and Hot Strip Mills, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

"Super-Lathe for Roll Turning," by Jack Binns, Owner, Binns Machinery Products, Cincinnati, Ohio

"Modernization of the Hot Strip Mill," by John H. Russell, Rolling Mill Operations Engineer, Steel Div., Ford Motor Co., Dearborn, Mich.

"Acme Steel Standardizes on 10 Slab Sizes for New Hot Strip Mill," by W. F. Hinkle, Vice President of Engineering, Riverdale Plant, Acme Steel Co., Chicago, Ill.

9:00 am—MECHANICAL SESSION— Crystal Room

Chairmen: S. W. Stouffer, Director of Construction and Maintenance, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

L. A. Fugassi, Chief Engineer, Midwest Steel Corp., Div. of National Steel Corp., Valparaiso, Ind.

"Design Considerations for Solid Bearings," by Bernard J. Sexauer, Bearing Engineer, National Bearing Div., American Brake Shoe Co., St. Louis, Mo.

"The Design of Coolant Systems as Affected by Various Cold Rolled Products," by J. Philip Wettach, Manager, Mill Lubrication, Engineering and Construction Dept., Dravo Corp., Pittsburgh, Pa.

"Recent Developments in Welding Techniques for Mill Maintenance," by R. A. Wilson, Vice President, The Lincoln Electric Co., Cleveland, Ohio

2:00 pm—OFF-THE-RECORD ROLLING MILL PANEL DISCUSSION—

ROLL APPLICATION AND SERVICE SESSION— Combined Meeting with Roll Manufacturers Institute Ivory Room

Moderators: Harry A. Machamer, Jr., Metallurgist, Birdsboro Corp., Birdsboro, Pa.

Howard S. Orr, Project Development Engineer, Rolling Mills, United States Steel Corp., Pittsburgh, Pa.

RMI Panel: Wm. H. Betts, Staff Metallurgist, United Engineering and Foundry Co., Pittsburgh, Pa.; J. W. Luoma, Technical Assistant-Roll Sales, Blaw-Knox Co., East Chicago, Ind., J. R. Pfouts, Superintendent Process Control, Ohio Steel Foundry Co., Lima, Ohio; E. P. Sandbach, Manager of Manufacturing, Mackintosh-Hemphill Div., E. W. Bliss Co., Pittsburgh, Pa.

AISE Panel: John F. McCarthy, Assistant Superintendent, Blooming, Hot Strip & Rolling Mills, Aliquippa Works, Jones & Laughlin Steel Corp., Aliquippa, Pa.; Clarence R. Mitchell, Divisional Superintendent—Rolling, Granite City Steel Co., Granite City, Ill.; H. E. Muller, Superintendent, Roll Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.; Arthur L. Roberts, Assistant Superintendent, Sheet & Tin Div., Bethlehem Steel Co., Sparrows Point, Md.; J. L. Walmsley, Supervisor, Stress Analysis and Testing, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

Topics:

1. Theoretical aspects of spalling.
2. Effect of scheduling and product mix on roll wear and spalling.
3. Effect of crowning practice on mill operation, roll wear and spalling.
4. Effect of various practices for applying cooling water on roll wear, spalling and operation.
5. Effect on the roll of rolling thin products.
6. Roll application as affected by mill operation.

Tied in with the above topics will be the effect of roll manufacturing practices, roll material and roll analysis.

7:30 pm—INFORMAL STAG DINNER— Gold Room

Speaker: W. M. Akin, President, Laclede Steel Co., St. Louis, Mo.

WEDNESDAY, APRIL 26

8:30 am—INSPECTION TRIP—

Granite City Steel Co., Granite City, Ill. Buses leave from Sheraton-Jefferson Hotel.

HARNESSING power to produce goods is as old as the domesticated animal. From the time this was achieved to almost today, man has directed this kind of supplementary power by snapping a whip, tugging reins or shouting commands. When the supplementary power was a machine, he pulled the handle, turned the wheel or threw the switch. It has been the long-sought goal that some day the harnessed help would know what to do without continuous prodding, attention and direction. This, of course, was almost attained in the case of the horse pulling home the buggy while the driver's attention was on another matter. Machines need more than repetition to develop a habit: they need control.

Almost overnight, the long-sought goal that machinery can be controlled to work of its own volition has become both a demanding necessity and a practical realization. In its vast complexes and huge machine assemblies, industry has slowly saturated the time-honored concept of adding more horsepower to do things faster or better.

Another way had to be found to meet the increasingly persistent demands for efficiency and productivity.

THE BLOOMING MILL PROGRAMMED

by MARSHALL BRITTAIN,
Manager,
Co-ordinated Digital Development Section
Systems Control Engineering
Motor and Control Div.
Westinghouse Electric Corp.,
Buffalo, N. Y.
and H. G. FROSTICK,
General Supervisor,
Design Engineering
New Mills Construction
South Works
United States Steel Corp.,
Chicago, Ill.

While mill speed and screw-down control are important factors—the greatest efficiency can be obtained when ingot and bloom positioning is a part of the over-all control system

A new control concept has been developed, together with the devices to implement it.

This new control notion is a system whose major function is central logic control: a central control system that has the ability to direct various individual functions through a coordinated sequence of events as dictated both by commands originating in the system and by various information fed back from the process under control. The devices which make this idea work are the newly developed static logic elements with their ability to be used in an infinite variety of patterns applied to any process. These are control components that have no moving parts, are small, rugged and extremely fast by present steel mill standards.

The blooming mill is a process to which this control has been applied. The blooming mill comprises a collection of mechanical functions such as main drive, table drives, screwdowns, manipulators, etc., each with its own prime mover and each with a separate control system. Until the advent of the 53-in. blooming mill at the South works of United States Steel Corp. with the general exception of screwdowns, each separate control system on this process had been directed by operators whose deftness of touch, fed by visual observations of the ingot, dials and meters determined the finished product, gage, the time of rolling and the over-all efficiency of the mill equipment. Now the process control of the blooming mill has been undertaken by a central control system which functionally duplicates each of the operator's movements in the rolling of an ingot.

In order to design this central control system and functionally duplicate the operator's contribution to the process, the basic rolling practice was analyzed. The analysis is a step in transforming the blooming mill

process from a highly repetitive "art" as practiced by an operator, into a science as directed by the controller.

The analysis of the process shows that each ingot requires a number of different kinds of passes through the mill. There is the first pass when the mill must receive an ingot at any location on the delivery table. There is the last pass when the finished bloom must be delivered to the shear table. There are nonturning passes, and finally there are turning passes. Each of these passes requires a different state for each of the individual drives used in the process. The drives must handle the ingot in a specific manner for every different condition. The ingot must enter the mill at a low speed, accelerate under control to its maximum speed and then decelerate to some exit speed. While the ingot is out of the mill it must be located with respect to its next prescribed operation, i.e., nonturn, turn or delivery.

To accomplish this each individual drive and its associated control systems must have certain capabilities. The mill main drive receives selective signals of entry speed, full speed and deceleration from the program card. In addition the main drive feeds back speed, load and voltage signals. The screwdown motors are able to position on a command signal from the program card to an accuracy band of $\pm \frac{1}{32}$ in. over a 53-in. opening range. The screws feedback intelligence as to actual location while moving and after stopping. The screws are capable of maximum traverse speeds of 600 in. per min and always come to rest in a downward direction. The left and right sideguards each driven by motors, are able to position a $\pm \frac{1}{2}$-in. accuracy band over a 112-in. range. The drive feedback speed signals and intelligence as to actual location during movement and after positioning. It has a maximum traverse speed of 210 fpm. The manipulator fingers are able to lift to one of seven heights, and it feeds back intelligence as to actual position during lift and when seated. The mill feed rolls and table rolls are capable of speed matching with the main drive, and depending on direction adjust themselves to a fixed draft compensation. These drives start and stop, independent of the main drive on signals from the program card. Product movements through the mill develop feedback signals of speed and position, which are obtained from tachometers and hot metal detectors.

The motion patterns which direct the product through the mill are supplied by the central control system. A punched card is used in the system to establish the mode to be followed. This is the first of the three kinds of information that the central control system needs to perform as the controller of the process. It is the data that sets the basic process procedure. The second type data used by the central control is that furnished by the different drive and product feedback signals. From these two sources of information the central control system is able to instruct and coordinate the various mill functions through a rolling cycle.

The punched card has advantages over other methods of system instruction. It can handle the large volume of information needed by the system, it is relatively easy to prepare using machines simple to operate and it is not difficult to change schedules or information punched on the schedule. The binary numbers inject themselves into usage because a large quantity of digital data must, of necessity, be reduced to the simplest possible expression. A typical set of cards is shown in Figure 1.

One of the most interesting and challenging aspects of the central control applied to the blooming mill is that of turning the ingot or bar. This problem typified the detailed advance study required.

To solve the turning problem, many hundreds of feet of high-speed motion picture film were taken in order to analyze and study the manner which several rollers used to make turns. The film showed the basic pattern for turns, and the inconsistencies among the rollers, even between successive turns. A detailed operational analysis was made, and the problem reduced to the rudiments of rotating many differently shaped work pieces in a pattern coordinated with the mechanics of the mill.

Ingot and bloom turning are depicted best by looking

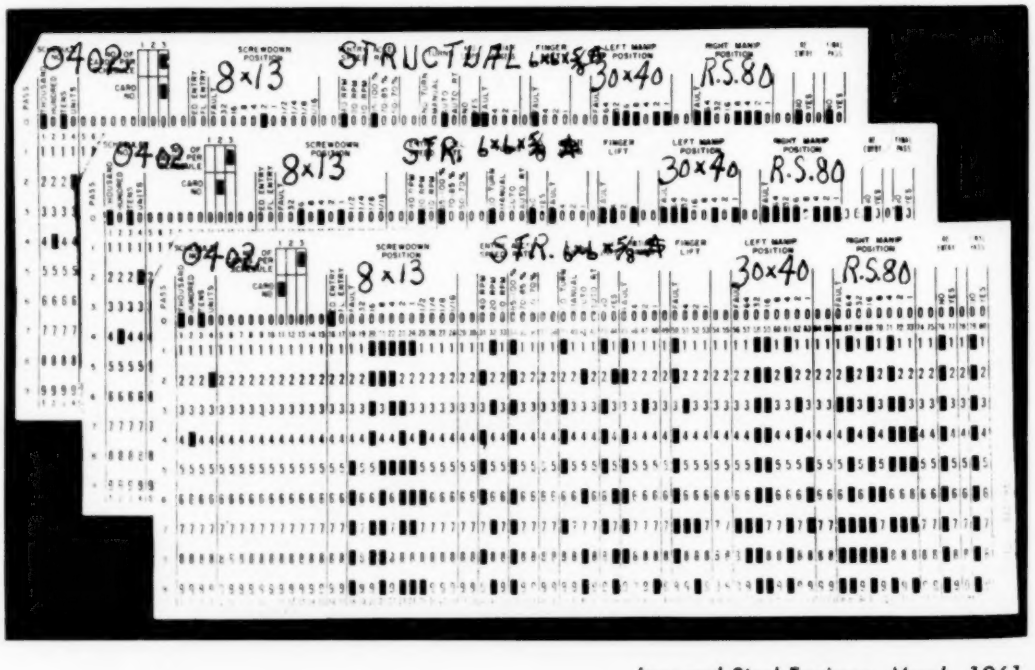


Figure 1 — A maximum of three cards are used for a total of 29 possible passes.

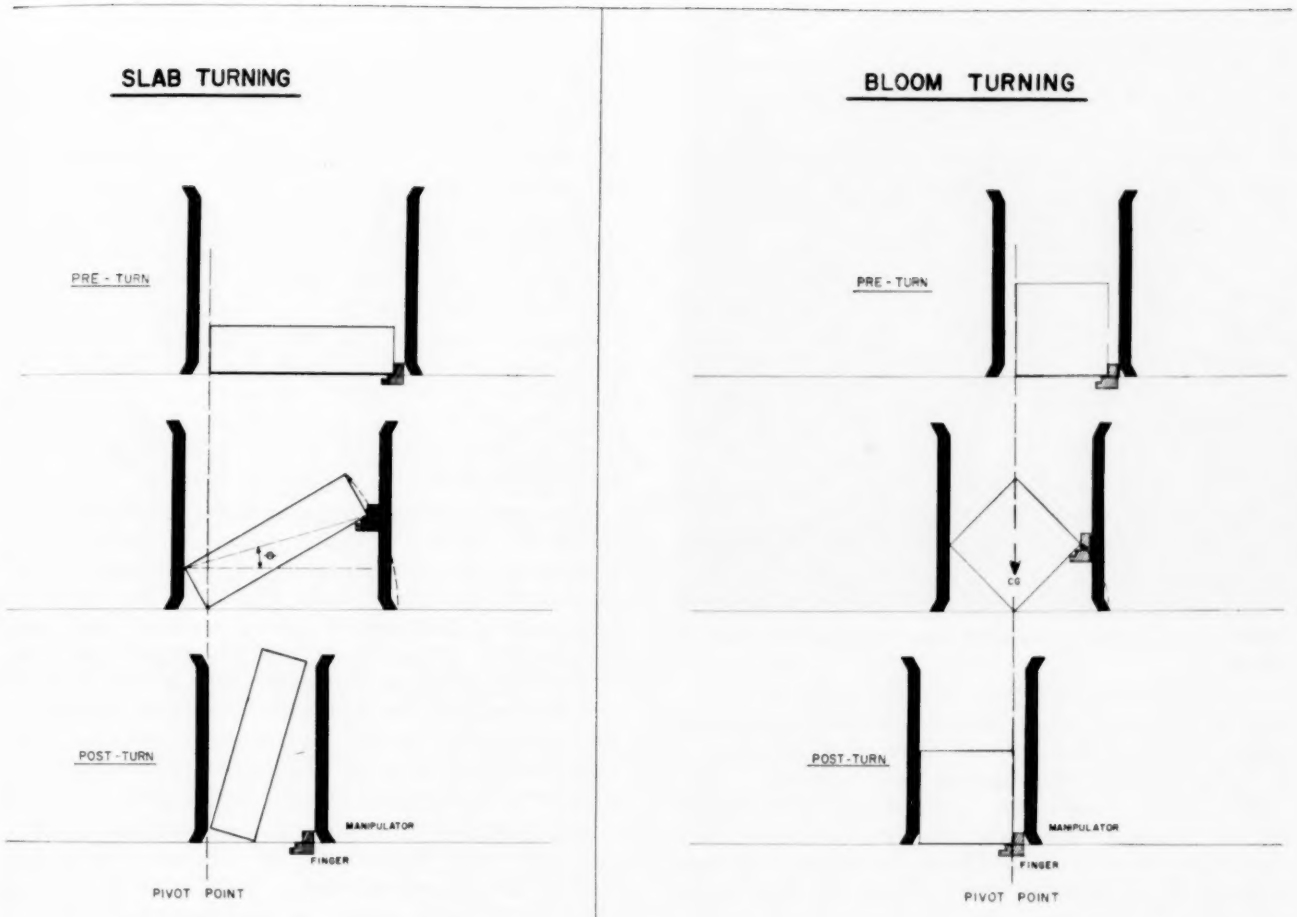


Figure 2 — Manipulation of slabs and blooms must be accomplished in the shortest possible time to increase available rolling time.

at the ingot from the "end." In Figure 2 it can be seen that, as the ingot rotates counterclockwise about its pivot point, the lower right hand corner, which is the contact point for the right manipulator and finger, scribes an arc having a radius equal to ingot width. Therefore, to effect the turn, the combined straight-line motions of the right manipulator in a horizontal plane and fingers in a vertical plane must result in the scribing of this arc. It should now be noted that as soon as the center of gravity of the ingot is just to the left of the pivot point (assuming no kinetic energy), it is able to continue the turn of its own weight and no additional finger lift is required. The right manipulator and finger follow through this motion, the finger seating and the right manipulator closing on the ingot. The whole function of the left manipulator during this operation is simply to get out of the way. However, in order to cushion the impact of the falling ingot on the tables, the left sideguard is position controlled in its outward movement to catch the ingot and let it slip to the table. The work pieces in this mill include both blooms and slabs.

As a result of the study the entire operation is sequenced as follows:

1. Manipulators close to insure contact with the ingot (preturn).
2. Left manipulator starts backing out for diagonal clearance.
3. Right manipulator and finger start the turn at a time to just allow diagonal clearance with the moving out left manipulator.
4. Left and right manipulators move to the post turn position following through on the turn.

This sequence of operations, while functionally correct to insure turns, does however contribute to lost rolling time, since the "post-turn" position of the ingot is in general not the same ingot position required for entry into the rolls for the next pass. Therefore, this basic sequence was modified in its terminal area to effectively accomplish the turn with a simultaneous lateral left or right movement.

This is best explained by examining a slab being turned from flat to edge. In this operation as shown in Figure 2, if there were no friction the manipulators could be closed as soon as the slab diagonal cleared the horizontal and the turn finished by "squeezing" on the slab. Friction, however, requires that the diagonal be raised to the angle θ with respect to the horizontal.

The turn sequence is now completed by calling for the next pass manipulator position as soon as the friction angle is reached. As the manipulators close to

Figure 3 — Control placement was designed for ease of access.

their next pass opening, they "squeeze" the slab to finish the turn. Simultaneously they are moving across the tables to line up the ingot for the next pass.

Because it is necessary to allow clearance for the fingers to reseat, this ideal solution cannot be quite reached in actual practice. Hence, the effective friction angle is increased to a point sufficient to allow finger clearance. The "measurement" of the friction angle is of course done by the finger position; therefore, this measurement is simply modified to provide for reseat clearance.

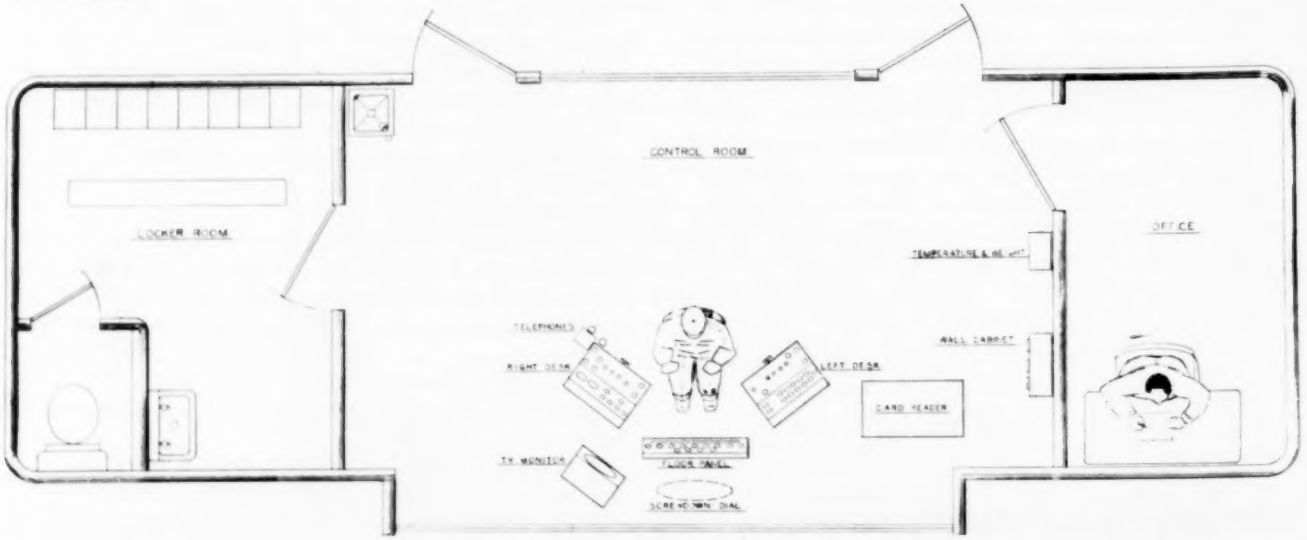
Among the things that make automatic turning difficult are fins on the ingot and camber in the bar. Observations on this mill show that the percentage of time that a fin is large enough to prevent a turn is negligible. Good open hearth practice is needed to achieve this. Observations also show that as long as an ingot is kept continually on the move during its complete rolling cycle, the camber of the bar does not occur in a degree sufficient to represent a problem. In the event that either condition does occur, the manual take-over abilities of the operator are such that the turn may be accomplished with a high degree of ease imposing no particular operational time or problem on the central control system.

Manual take-over is the last of the three kinds of information the central control system must handle. The wide variances that can occur in rolling conditions make mandatory that some signal representing an operator's judgment can take precedent over other data being processed through the logic devices. An examination of the pulpit layout and of the control arrangements will show that the means by which this is done has given a new look to the operator's pulpit, the operator's desk and the operator's job itself.

The apparatus that is located in the pulpit are those things to which continuous access is required for sequencing the process and for other operational attentions. The card reader falls into this category along with a multitude of switches, signal lights and instruments. The equipment which supplements the card reader and other control elements is placed in the motor room with the logic and sequencing equipment, the regulators, control relays, amplifiers and the other electrical equipment. The devices which are in the pulpit and their functions are shown in Figure 3.

The pulpit is located so that it straddles the mill approach table. It is equipped with air coolers and heaters for operator comfort, and it is pressurized with cleaned air taken from the adjacent motor room. The cleaned air minimizes maintenance on the card reader and other equipment containing low voltage contactors. Vibration which originates in the mill table rolls is almost completely blocked from the pulpit by the neoprene-fabric pads placed under the pulpit support columns. Adequate sound proofing is integral in the pulpit design. The lighting is adjustable for viewing ease and working conditions. The glass panels which comprise most of two exterior walls are double thick and are heat and impact resistant. A partition in

Figure 4 — Adequate facilities for the comfort and convenience of the operator, and ease of operation were installed in the pulpit.



the pulpit furnished a separate room for desk and file space for preparation and storage of mill control cards. A second partition creates a small locker room containing sanitary facilities, table and bench, Figure 4.

The distinctive features which give the South works blooming mill pulpit the appearance of newness are the card reader and the control desks. The card reader's function is to furnish information for production of a bloom. Close to the card reader, placed where a good view may be had of the mill and toward the rear along the mill approach tables, are the control desks and the operator's chair. The card reader is wheel mounted and connected into the circuitry by means of a flexible cable. As the cards may be placed in the reader in the order in which the product will be run, it is not necessary that the reader be within reach of the man seated at the desk. A stack of cards placed in the reader can be used in the control system at the discretion of the operator.

The control desks are perhaps the most visible evidence of the new thinking which characterizes this equipment. The desks are designed with the console technique. They are sleek, compact and give easy control of the many multi-motioned, power amplified operations. Perhaps the two developments which permitted the use of this design approach are the miniature master switches and the use of the interposing devices in the manual control arrangements.

The miniature master switch was developed for this job. It replaces the multi-positioned hand or foot operated switch. The switch functions basically to override data normally furnished by the control card. It has a rating of 20 amp at 250 volts and can be arranged for spring or stay-put operation, a neutral and four operating positions and for four circuits either opening or closing.

A basic concept in using this switch and the subsequent layouts these switches make possible on the control consoles is that this mill is first and fundamentally a programmed mill, and that the manual signals which occasionally are imposed on the process by the operator shall supplement the information usually taken from the control card. Therefore, these switches do not handle heavy current signals. They are in the preamplifier level of circuitry. Their space requirements are considerably less than those of switches on a manually controlled mill.

The grouping of the switches and the arrangement of switch movements follows the usual practice of making the control as natural a simulation of the mill arrangement and mill movements as may be possible. The mill approach switches are on the left console, the mill delivery switches on the right and the approach table switch precedes the feed roll switch. Left and right manipulator switches are similarly placed and left and right movements are arranged for control in the same direction. Those units most frequently used are most conveniently placed, and the switches for the manipulator finger drive which conceivably may require operation while both the left and right manipulators are under hand control are set up as foot switches on flexible cords.

For ease of identification, both visual and by touch, the switches have been equipped with differently colored and variously shaped plastic handles. The shapes are designed to create the image of the item under control. This makes for a wide variety of handle shapes and gives the control desk a distinctively unique appearance.

As shown in the switch and signal tabulation, about one third of the controllers are used in mill setup or in those steps needed to start the mill preparatory to rolling. There are groups of signals which originate in the logic elements. These are items read out of the control to show the operator what is programmed in the mill. Further, a group of signals, which originate on the mill, show product location or screw position. There are rheostats and selectors which permit adjustments within the settings established by the program card. Lastly, there are switches which are used for manual intervention. These are the switches having the differently shaped handles.

In using these desk switches, the operator can take over manual control of any mill function. He can retain control of this function while he operates the switches, and restore control of the function to the control card when he releases the switches and depresses the correct reset button.

Two functions, manipulator repositioning and intervention on table rolls, do not cause a stoppage in the programmed sequence. Continuance of the program schedule permits handling the bar to aid it in entering the mill rolls or to correct for camber. Under these conditions, the operator works as an adjunct to the positioning data programmed on the card. All other mill functions, screw settings, mill roll and feed roll operations, are arranged so that a manual intervention causes a stoppage of the sequencing which can only be restored by an operator command. It is done this way because anything changed on these items will effect the remainder of the rolling schedule and a decision is required concerning when the pre-established program can be continued.

It should be evident that the man at the control desk of a programmed mill is associated with the process in a vastly different manner than is the operator of a manual mill. The programmed mill operator is an observer. The entire sequence of the operation is laid out by the programmed cards and controlled by the logic elements and regulators. The operator is not required to perform the repetitious and fatiguing control operations that are required for each movement of each function on the manual mill. He intervenes only when there is a deviation in the program, when judgment is required or when a reposition or adjustment is needed to continue the operation. The holes in the cards and the circuitry do the work. The man watches and exercises judgment.

One fundamental objective of the centralized control form as applied to the blooming mill is the ability to prescribe the operation of the mill in very certain and definite terms. This is generally construed to mean drafting practice and the final product dimension. This has obvious advantages, but by no means must be considered as the final objective. The real goal, both in the design stages and finally in operation, is to create an over-all advantage in the complete rolling operation. Merely setting up the operation through a card is secondary when compared to the coordinating require-

TABLE I

53-in. Blooming Mill Pulpit Operator's Controls

Reference no.	Purpose	Device	Location	Function
	Setup			
1	Main mill control	Selector switch (jog-stall-creep)	Wall cabinet	Sets up type of mill operation
2	Main mill jog control selection	Selector switch (local-remote)	Wall cabinet	Transfers jog control between pulpit and mill floor
3	Main mill jog control	Pushbutton (forward-reverse)	Wall cabinet	Jog mill
4	Mill tables lubricant	Indicating light	Left control desk	Indicates lubricant pump ready to run
5	Screw-downs and manipulators lubricant	Indicating light	Left control desk	Indicates lubricant pump ready to run
6	Screw-down dial adjustment	Hand crank	Overhead coving	Adjusts dial setting to coincide with actual roll opening
7	Upper roll control	Breaker control (test-trip-close)	Wall cabinet	Energizes upper roll generators
8	Lower roll control	Breaker control (test-trip-close)	Wall cabinet	Energizes lower roll generators
9	Mill master relay	Indicating light	Left control desk	Indicates main mill ready to run
10	Tables master relay	Indicating light	Left control desk	Indicates front, rear and feed tables ready to run
11	Screw-down master relay	Indicating light	Left control desk	Indicates screwdowns ready to run
12	Fingers master relay	Indicating light	Left control desk	Indicates fingers ready to run
13	Left manipulator master relay	Indicating light	Left control desk	Indicates left manipulator ready to run
14	Right manipulator master relay	Indicating light	Left control desk	Indicates right manipulator ready to run
15	Master relay reset	Indicating light	Wall cabinet	Indicates main mill off normal
16	Mill approach table control	A 3-point selector switch	Right control desk	Preference selection with ingot buggy
17	Mill delivery table	A 3-point selector switch	Left control desk	Preference selection with scarfer and shear
18	Tables operation	A 3-point selector switch (auto-manual)	Left control desk	Selects control for front, rear and feed rolls
19	Rolling operation	A 3-point selector switch	Left control desk	Selects drives under programmed control
20	Tandem rolling	A 2-point selector switch (normal-tandem)	Right control desk	Sets up automatic cycling to accept tandem rolling
21	Tandem rolling separating pass	Multi-tap selector switch	Right control desk	Stops automatic cyling on desired pass
22	Ingot call	Multi-tap selector switch	Right control desk	Informs ingot buggy operator to deliver new ingot
23	Screw-down clutch control	A 2-point selector switch	Wall cabinet	Couples screw-down motors
24	Mill to start alarm	Pushbutton	Right control desk side	Sounds alarm in mill area at startup
25	Roll water control	A 2-point selector switch	Left control desk	Starts roll cooling water
26	Entry speed selection, manual rolling	A 2-point selector switch	Right control desk	Selects entry speed as fraction of base speed
27	Acceleration rate control, manual rolling	A 3-point selector switch	Right control desk	Selects rate at which main drive accelerates to base speed
	Programmed operation			
28	Control power on	Indicating light	Floor panel	Indicates control power was interrupted
29	Entry speed adjustment	A 3-gang rheostat	Left control desk front	Fine adjustment of programmed entry speed
30	Read card	Pushbutton	Left control desk	Starts card reader and transfers information to storage
31	Wrong schedule	Indicating light	Left control desk	Indicates all cards not from same schedule
32	Pass advance	Pushbutton	Right control desk	Causes control to read pass information and step pass
33	Fault	Indicating light	Floor panel	Indicates card is read or punched wrong or storage malfunction
34	Return to separating pass	Pushbutton	Right control desk	Sets up cycle in tandem rolling
35	Screw-down vernier adjust	Synchro-tie coupled hand dial	Right control desk front	Fine adjustment of programmed screw-down setting
	Manual intervention			
36	Emergency stop	Pushbutton	Right control desk	Interrupts control circuit to stop drive
37	Automatic by-pass	Pushbutton	Left control desk	Allows manual settings of manipulators and screwdowns to remain
38	Mill approach table	A 5-point miniature switch	Right control desk	Transfers control from automatic to manual and operates tables
39	Mill run in table	A 5-point miniature switch	Right control desk	Transfer control from automatic to manual and operates tables
40	Mill run out table	A 5-point miniature switch	Left control desk	Transfers control from automatic to manual and operates table
41	Mill delivery table control	A 5-point miniature switch	Left control desk	Transfers control from automatic to manual and operates table
42	Front and rear feed rolls and table control	A 5-point miniature switch	Left control desk	Transfers control from automatic to manual and operates drives
43	Left manipulator control	A 5-point miniature switch	Left control desk	Transfers control from automatic to manual and operates drive
44	Right manipulator control	A 5-point miniature switch	Right control desk	Transfers control from automatic to manual and operates drive
45	Screw-down control	A 5-point miniature switch	Left control desk	Transfers control from automatic to manual and operates screws
46	Main mill control	A 5-point miniature switch	Right control desk	Transfers control from automatic to manual and operates mill

TABLE 1—Continued

Reference no.	Purpose	Device	Location	Function
47	Finger lift control	Foot operated pushbutton	Floor mounted	Transfers control from automatic to manual and initiates fingers
48	Billet turner control	A 2-point selector switch	Left control desk	Transfers control from automatic to manual and operates drive
	Restore to programmed operation			
49	Automatic reset	Pushbutton	Right control desk	Restores to automatic control after manual intervention
50	Return to start	Pushbutton	Left control desk	Resets controls to original setup
51	Controller reset	Pushbutton	Right control desk	Resets protective devices on main drive and auxiliaries
	Program readout			
52	Pass indicator	Elevator type indicator (pass 0 to 29)	Floor panel	Indicates which pass control is reading
53	Edge pass	Indicating light	Floor panel	Indicates that ingot should be on edge for first pass
54	Flat pass	Indicating light	Floor panel	Indicates that ingot should be flat for first pass
55	Turn pass	Indicating light	Floor panel	Indicates turn to be made at end of pass
56	Final pass	Indicating light	Floor panel	Indicates control on final pass
57	Billet turn	Indicating light	Floor panel	Indicates when manual billet turn must be made
	Mill readout			
58	Screwdowns ready	Indicating light	Floor panel	Indicates that screws have reached their programmed position
59	Screw-down indicator	Illuminated dial	Overhead coving	Indicates roll opening
60	Forward slowdown hot metal detector	Indicating light	Floor panel	Indicates presence of hot metal in its zone
61	Forward stop hot metal detector	Indicating light	Floor panel	Indicates presence of hot metal in its zone
62	Reverse slowdown hot metal detector	Indicating light	Floor panel	Indicates presence of hot metal in its zone
63	Reverse stop hot metal detector	Indicating light	Floor panel	Indicates presence of hot metal in its zone
64	Upper roll generator voltage	Voltmeter	Wall cabinet	Indicates generator voltage (800-0-800)
65	Upper roll generator current	Ammeter	Wall cabinet	Indicates generator current (12,000-0-12,000 amp)
66	Upper roll speed	Tachometer	Wall cabinet	Indicates upper roll speed (100-0-100 rpm)
67	Lower roll generator voltage	Voltmeter	Wall cabinet	Indicates generator voltage (800-0-800)
68	Lower roll generator current	Ammeter	Wall cabinet	Indicates generator current (12,000-0-12,000 amp)
69	Lower roll speed	Tachometer	Wall cabinet	Indicates lower roll speed (100-0-100 rpm)
	Ingot conditions			
70	Temperature	Indicator and recorder	South wall	Indicates ingot temperature before entry into mill
71	Weight	Indicator	South wall	Indicates ingot weight before entry into mill
	Communications			
72	Delivery side television	Television monitor	Overhead	Shows delivery side of mill
73	Plant intercommunications and paging	Handset and box	Right control desk	Provides communication with other mill areas
74	Telephone	Handset	Right control desk	Provides outside communication

ments of the control to obtain optimum performance of the mill. The card is but a means to predetermine the schedule of the mill. The bigger job is in making all the parts of the mill work at peak output.

This, of course, injects the time domain in the mill control system. It is therefore worthwhile to analyze the performance of this mill with respect to product output. While it is obviously not correct to look at just one part of the problem, for the purposes of this discussion, the important factors of material flow both toward and away from the mill will not be considered.

The time factors affecting the mill performance may be broken down into three broad areas. These are:

1. The performance of the individual drive systems.
2. The coordination of these drives during repeated nonturning passes.
3. The coordination during the turning process.

Analysis of the various individual drives on the mill such as the screwdown, manipulators, fingers, table rolls and main drive all show that they operate in what might be called short range movements, movements which do not allow the drive to stay at its maximum speed for any appreciable amount of time. Thus, the design requirements and the results show that each drive must stay in its maximum commutating current range, close to 100 per cent, during the accelerating or decelerating periods. In effect this is laying down the rule that maximum available torque shall be transmitted to the mechanical member at all possible times.

For the blooming mill, the coordination between drives for optimum rolling lies among the main drive, screwdown and tables. Operations show that the coordination must be so adjusted that the screws start to position the instant the ingot leaves the roll bite,

and that the ingot re-enters on the next pass the instant the screws have attained the desired setting. The function of the tables is merely to control the movement of the ingot so that this purpose is accomplished. The main drive, both for proper entry condition and to prevent excessive ingot kickout, must enter and exit the ingot at known speeds and accelerate and decelerate while the ingot is in the mill.

In reversing mills, the amount of time the ingot is being handled out of the roll bite is a significant factor in the total rolling time. This is particularly true when turns are to be made, more so on a high-lift bloomer since turns may occur on an average of once every three passes. Analysis of turning time must include the full turning cycle from the time the ingot leaves roll bite to the time it re-enters on the next pass.

A criterion for optimum turning might be simply that at least one manipulator show a continuous movement during this cycle. The more rigid rule is that continual manipulator movement and its resulting maximum torque transfer must be analyzed in relation to the turning process previously described. The results show this continual motion from the time steel leaves the roll bite until it again enters the roll bite.

The performance of this mill as outlined above has been logically examined and analyzed through detailed recordings of the mill cycle. While these are the "proof of the pudding," so to speak, the visual performance of the mill helps to substantiate the factual data. Each ingot seems to flow through the operation under the silent and unmoving observation of the mill operator.

The 53-in. blooming mill has proved that the individual functions of a manufacturing process can be coordinated by a central control system. The system uses three sets of signals, those originating on the control cards, those fed back from the individual control systems and those interjected by the operator. It brings together all these signals, sifts them through the logic elements and causes the manufacture of a bloom or slab to flow in a smoothly coordinated process. The ease and speed with which this is done gives promise that this mill will eventually exceed its designed production rates. Because all the mill movements are planned with engineered deliberation, it is expected to meet its performance goals with a minimum of breakage and a minimum resultant downtime.

Discussion

PRESENTED BY

D. J. FAPIANO, Application Engineer, Metal Rolling and Process Engineering Unit, User Industry Sales Dept., General Electric Co., Schenectady, N. Y.

D. J. Fapiano: For this installation, the intelligence on the punched card was presented in straight binary form. While this presents no problem on relatively low accuracy systems, it could prove awkward for a high accuracy system. For example, a recent structural mill has screwdown positioning accuracy requirements of ±0.0005 in. The binary equivalent would require punching the card in units of 1/1024 in.

The commutator type digitizer used on this installation requires periodic replacement. Our evaluation of the devices available at the time this project was installed indicated that good preventive maintenance would require twice a year replacement of each shaft digitizer associated with the reversing mill auxiliaries. For a complex system where 20 to 25 position feedback devices might be required, this replacement cost in parts alone would seem prohibitive. Recently introduced noncontacting equivalents of this device may eliminate these objections, but until these devices have been proved in service, selsyn or potentiometer position feedbacks would seem to offer greater reliability.

With card program controlled mills, it is desirable to make provision for slight manual readjustment of the roll openings punched in the card without altering or repunching the card.

We are pleased to have had the stimulus of South works' interest in pilot device miniaturization which led to our developing the miniature master switch used throughout the new structural and blooming mills.

Discussions of card programming techniques inevitably lead to the even more intriguing area of computer control. The ideal concept being one in which the computer not only directs the process, but continually monitors it, compares the actual results with those computed and makes appropriate adjustments in the programmed relationships.

Early in 1958 we completed a development installation of such a computer control system. In the year following, during the computer directed rolling of some 3000 bars, the techniques were perfected and the mathematical relationships necessary for the successful control of a reversing plate mill and a slabbing mill were refined.

The plate mill offers opportunity for the most sophisticated computer application. Here we apply feedback techniques to the control of motor load, roll separating force, plate width while broad side rolling, final plate gage and plate contour. Rather than attempting to obtain the desired results by prior programming, the computer regulates these critical factors to make them conform to the desired values. For universal slabbing mills and reversing roughing mills, similar but somewhat less comprehensive computer programs are proposed.

For high-lift slabbing and blooming mills, structural mills and beam mills, where the roll design dictates that specific intermediate dimensions be met during the rolling schedule, a different approach is indicated. The process control computer would be used to generate the controlling instructions prior to the actual rolling. This intelligence would then be used, as required, by the main drive and auxiliary control system. This system of necessity more restricted in its operation than that first described, nevertheless eliminates the card preparation and handling required by earlier automation systems.

Both systems are available today. We are convinced that, having proved the value of card program control, the industry will be quick to recognize the even greater benefits to be derived from these more advanced techniques. ▲

Pneumatic and Hydraulic Material Handling Systems in the Steel Industry

by L. E. MYLTING, Vice President, The Allen-Sherman-Hoff Co., Wynnewood, Pa.

WIND and water are continuously and inexorably changing the face of our earth. Not as dramatic as earthquakes or volcanic eruptions, they are nature's principal means of moving materials.

The power of air in motion is in evidence from the "Dust Bowl" of our own mid-west to the deserts of North Africa. Measurements in the "Dust Bowl" have established handling rates as high as 100 lb of dust per sq ft per hr.

Beaches and rivers bear evidence of the tremendous carrying capacity of water in motion. Probably nowhere on earth is there a more startling example of hydraulic conveying than the Yellow river of China, where silt concentrations have reached 50 per cent by weight.

The controlled application of these natural media to the steel industry is most important in materials handling operations.

OPEN HEARTH DUST

Increasing restrictions for the prevention of atmospheric pollution have led to extensive use of dust collectors for open hearths. To bring the dust from the collectors to a central, convenient point of disposal, it has been necessary to install conveying systems. Figure 1 shows a typical dust conveying system which has been installed at the Fairless plant of the United States Steel Corp.

Conveying air flow is produced by positive displacement pumps exhausting air from a cyclone separator. Material is received into the cyclone from a piping system connecting to dust valves located beneath the dust collector hoppers.

. . . . reduced manual procedures, convenience of location and low first cost—these are important factors in favor of pneumatic and hydraulic handling systems . . . .

The valves are controlled by an automatic system, permitting operation of only one valve at a time. Sequencing is accomplished by using the change in pressure between high vacuum, resulting from conveying dust, and low vacuum, resulting from an empty line when no material is left in the hopper. Control is achieved on the basis of actual time required for emptying a hopper, no matter what that may be.

Dust is periodically and automatically discharged from the cyclone into a storage bin. It then passes through a conditioner where water is added to dampen the material sufficiently to permit dust free and sludge free transportation.

Systems of this type require approximately 75 to 125-hp blowers and utilize 4 to 6-in. conveying pipe. An air washer is interposed between the cyclone and the air pump to remove the carry-over from the cyclone, a necessary protection for a mechanical blower.

Conveying capacities may range from 10 to 30 tons per hr, depending on length of line and weight of dust. The bulk weight of open hearth dust varies considerably; it has been found to be as high as 125 lb per cu ft at open hearths using oxygen lancing. This is an important factor in system design, and requires careful consideration of both weight and packing characteristics.

BASIC OXYGEN PROCESS

With the development of the basic oxygen process, the limited space available for materials conveying presented a natural application for pneumatic systems.

Figure 2 shows the additives conveying system for the first L-D process application in this country at the McLouth Steel Corp. This is a vacuum system, conveying 12 tons per hr of burnt lime and limestone from secondary storage hoppers to additive bins adjacent to the three 35-ton oxygen vessels. The capacity of this system is based on supplying two vessels simultaneously. The burnt lime conveying rate is 12 tons per hr.

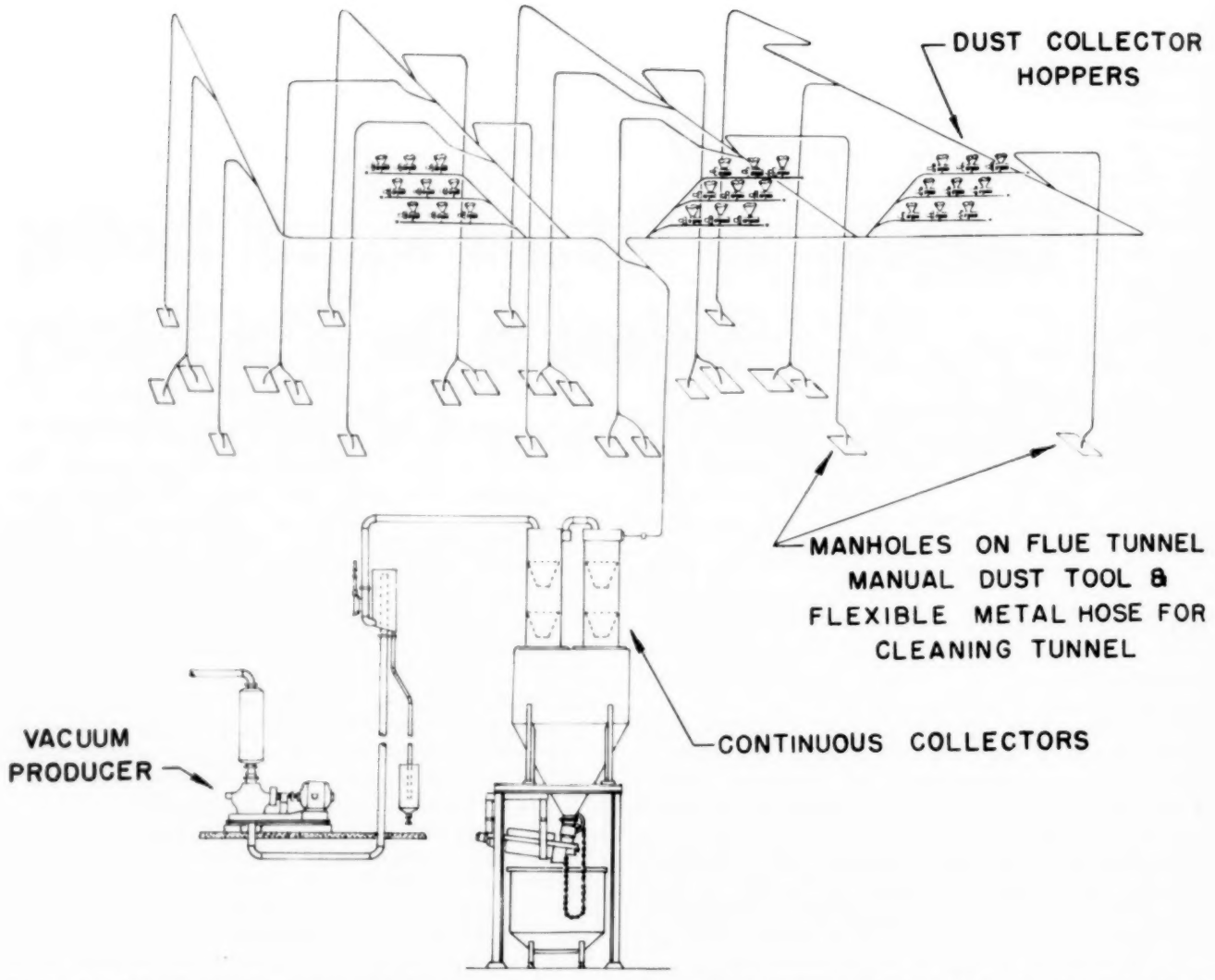
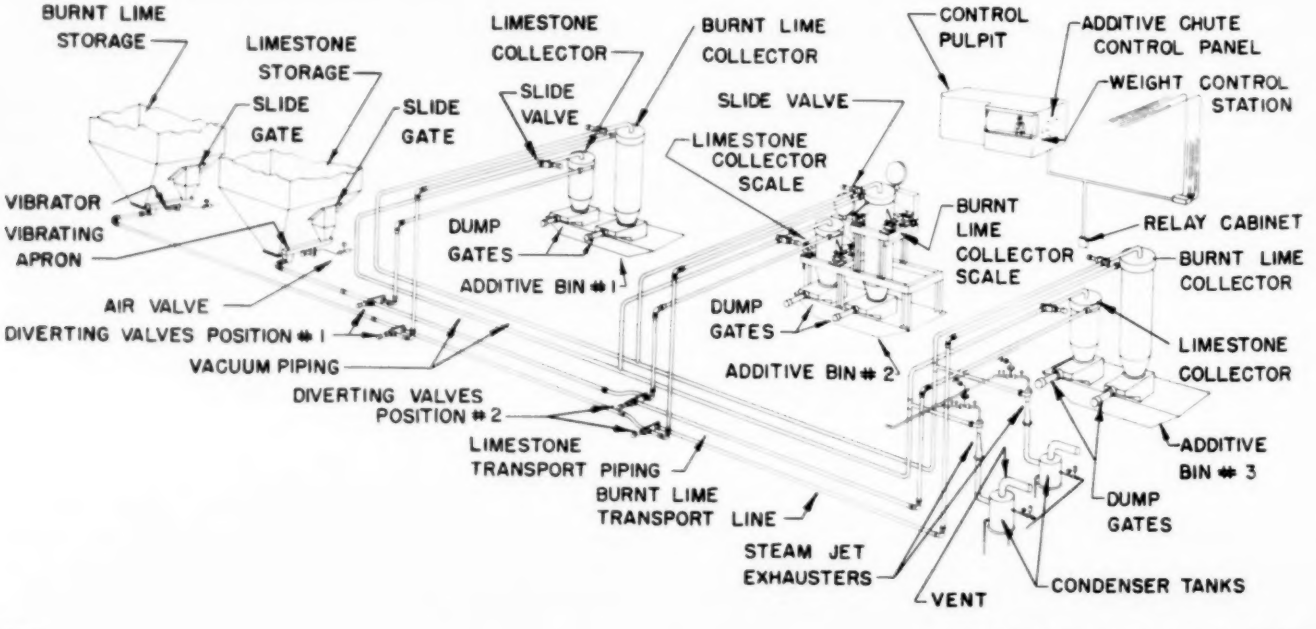


Figure 1 — Automatic dust collection is accomplished by the use of a valve sequence system which permits operation of only one valve at a time.

Figure 2 — A pneumatic conveying vacuum system supplies 400 lb per min of burnt lime and limestone to any one of three vessels at an oxygen converter installation.



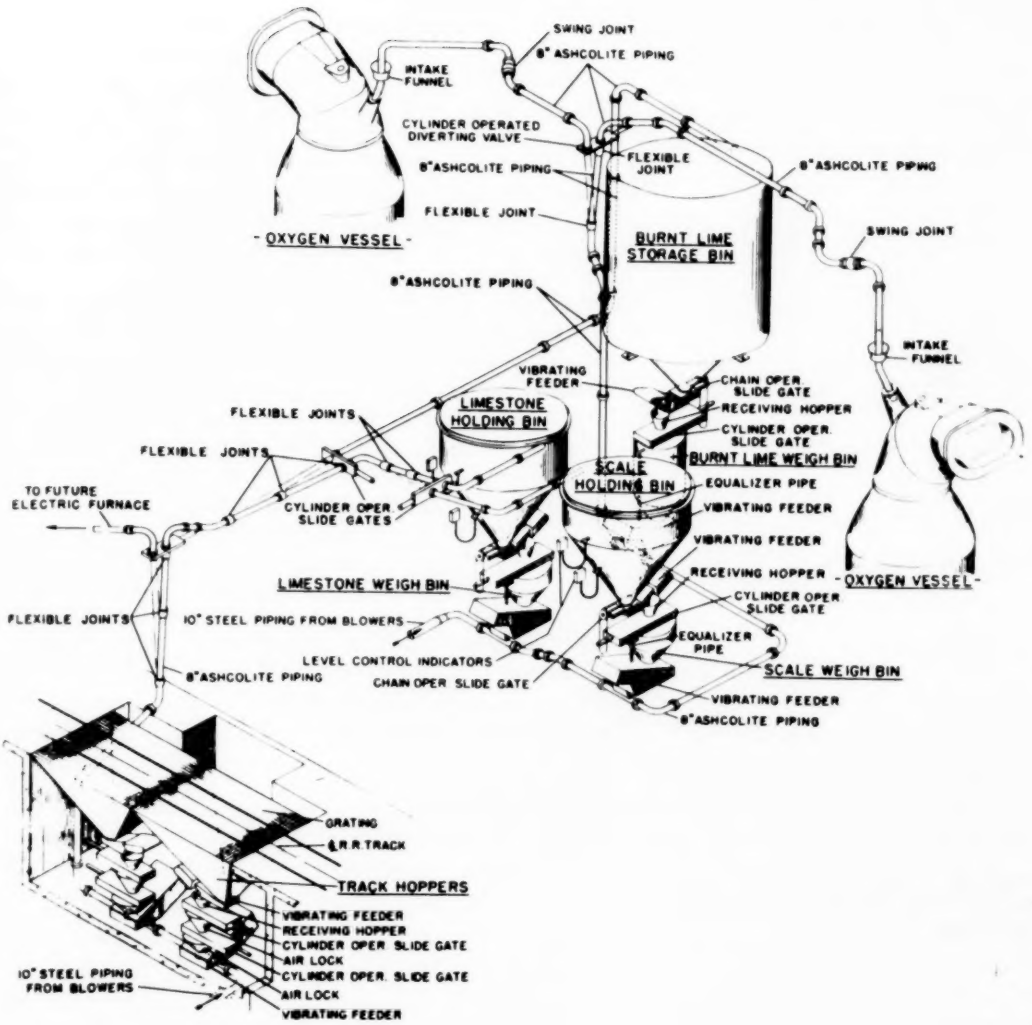


Figure 3 — A pressurized system has made possible the greater handling rates required for large oxygen converter vessels.

Material is automatically fed into the system by pneumatic vibrating feeders, maintaining maximum load in the 4-in. conveying lines. It is transported to a set of cyclones suspended on scales above the additive bin of each vessel. Upon reaching a predetermined weight, cyclones automatically discharge into the bins.

Air flow is produced by steam jet pumps. Controls, located in the pulpit, enable the operator to convey material to any additive bin at will.

A subsequent installation at the McLouth Steel Corp. is shown in Figure 3. This is a completely integrated system for conveying burnt lime and limestone from track hoppers to holding bins and from weigh bins, beneath the holding bins, directly to the oxygen vessels.

Distribution of materials from the track hoppers to appropriate holding bins is controlled from a cubicle located near the track hoppers. This cubicle is equipped with pilot valves ganged on a shaft to properly operate the shuttle valves. An electrically lighted mimic system indicates shuttle valve positions.

Two control cubicles (one for each vessel) located in the control room permit the operator to control filling of weigh bins and feed to the oxygen vessels at controlled rates and in controlled quantities.

To fill a weigh bin, the operator simply pulls a button on the panel. This activates a pilot valve which, in sequence, opens the weigh bin gate and starts the electrically operated vibrating feeder under the holding bin. When a predetermined weight of material is received in the weigh bin an air toggle automatically returns the manual button. The gate and feeder are returned to normal in the reverse sequence. Weight of material is indicated on dial scales on the panel.

The gate on the full weigh bin being closed, the bin can now be pressurized, and material fed into the air stream by the vibrating feeder beneath the bin. Automatic rate control is provided to permit the operator to preselect any rate of feed within the capacity of the system. Observation of the dial scale shows exact amount fed.

All control functions of this system except feeder amplitude are accomplished pneumatically; experience with electrical components on the first vacuum system was not satisfactory.

The change from a vacuum to a pressure system had several advantages. Direct delivery of additives to the oxygen vessels was made possible. Also, the location of the positive displacement mechanical blowers upstream from material flow thus removed them from damage from carry-over.

A number of components used in this system are interesting. In the scale system used for the weigh bins, flexible steel cables are used on a regular beam scale system instead of conventional knife edges, and the final force is transmitted to a pneumatic transducer

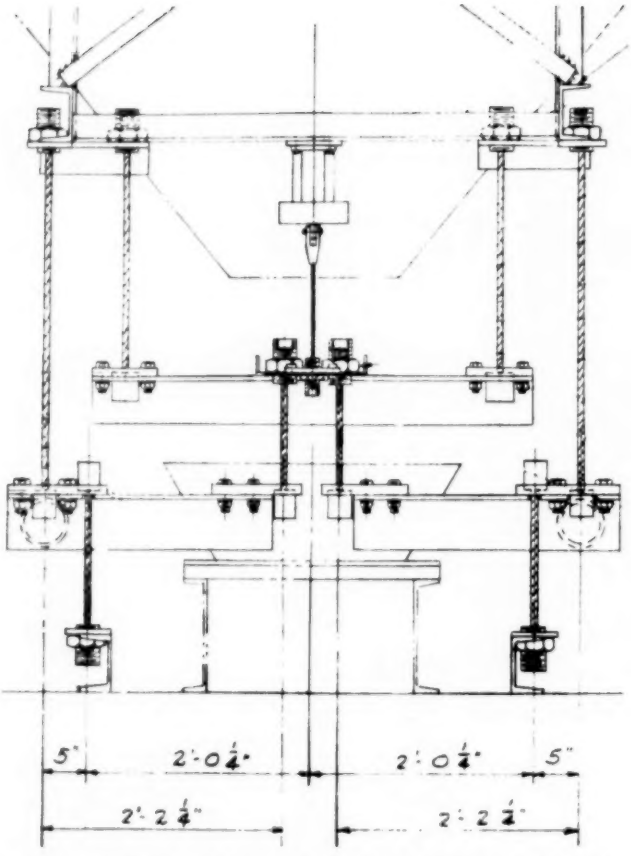


Figure 4 — Steel cables replace knife edges and the scale read out is obtained from a pneumatic transducer operating on the null balance principal.

located at the normal takeoff point in a lever system as shown in Figure 4. Force is converted linearly to air pressure, the unit operating on a null balance principle.

A control valve bleeds air out or in, as needed: out to reduce pressure needed to balance the weight, in to supply air to increase the pressure as needed. It is possible to connect any number of indicating gages and air control devices to this air chamber, permitting location of indicating gages at remote places. The very small movement required to operate the pneumatic transducer (measured in thousandths of an in.) results in very slight cable deflection and thus accurate weighing.

In changing from the conveying of one material to another, a small cam bank, Figure 5, operating 3-way and 4-way valves is used.

In changing from one vessel to another, a number of control lines require shifting. For this purpose a larger cam bank is required. This bank is not operated directly, but through a reduction gear to overcome the greater torque required for the greater number of valves.

All valves on both cam banks are operated positively in both directions by slotted cams. This offers a greater degree of reliability than single surface cams with spring return.

An air sealed gate is used on top of the pressurized weigh bins. This gate has a door which seals against double lips. Air is admitted between the lips (at a higher pressure than that in the bin) to prevent leakage of dust contaminated air to the atmosphere. Provision is made to replace all wear parts, through hand holes and access doors, without removing the gate.

The 2-position shuttle valve is shown from the double connection side in Figure 6. The pipes connected to this side are rigid. The flexible pipe connection is made to the other side of the valve. The cylinder moves the slide to connect the flexible pipe to either of the opposite rigid connections. The nonconnected pipe is closed off tight at all times. Cams lock the sliding and the fixed parts of the valve tightly against each other.

To toggle the air controls when a weigh bin is full, an automatic controller is used. This device can be set for numerous additional control functions such as changing pressures, inverting pressures, etc.

Long radius, removable wearback 90 degree elbows are used in the pipe lines. The removable wearback can be replaced in case of wear; it also offers ready access to the pipe line for inspection or emergency.

The pressure system is now being extended to a third oxygen vessel. The 8-in. conveying lines from weigh bins to vessels are being changed to 10-in. lines and augmented to take care of simultaneous operation of two vessels. The 8-in. lines from track hoppers to holding bins will remain.

Capacities of additive systems for the oxygen process are generally based on burnt lime requirements.

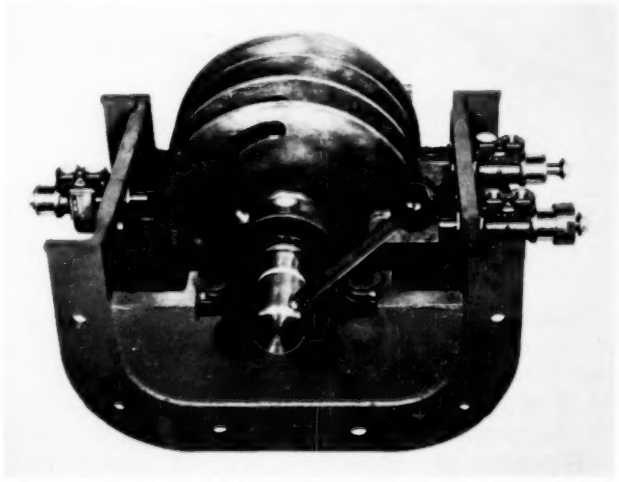
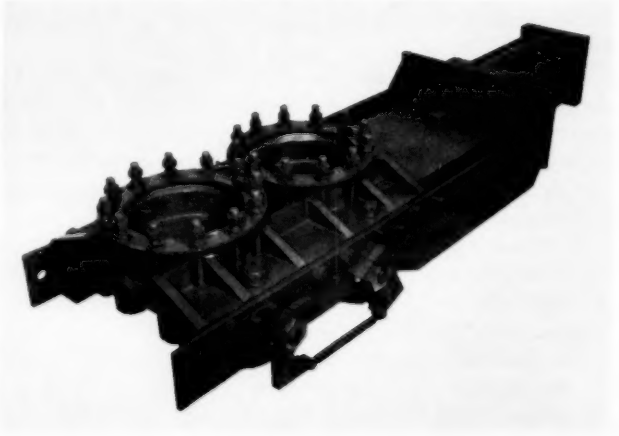


Figure 5 — Cam-bank controls actuate the diverting valves necessary to enable the system to handle two materials.

Figure 6 — Shuttle valve permits discharge through the valve to either of two exhaust connections diverting the material flow as desired by the operator.



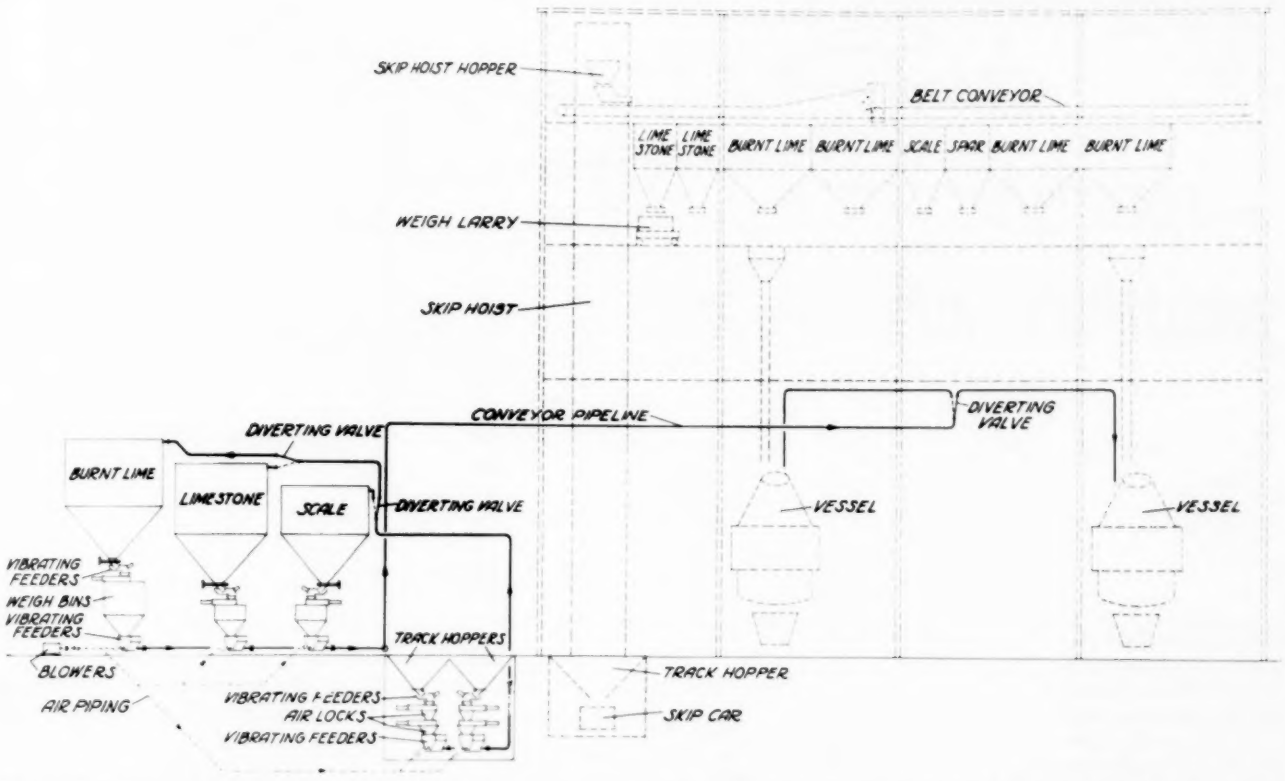


Figure 7 — Comparison between a mechanical and a pneumatic handling system indicates that the ability to place the pneumatic system in any convenient location can result in a large reduction in space requirements.

Approximately 1500 to 2000 lb per min of burnt lime can be conveyed through an 8-in. line, 2500 to 3000 lb per min through a 10-in. line and up to 5000 lb per min through proportionally larger lines. Stone, pellets and scale will handle in the same system at approximately half the rate of burnt lime.

Approximately 200 hp are required for blowers for the 8-in. system and proportionally higher hp for larger lines. To avoid high hp rates it is important that lines be kept as short and direct as possible.

There are a number of extremely sound reasons why pneumatic systems are particularly applicable for the basic oxygen process of steelmaking. A great deal of activity is involved in a very limited space; it is extremely important that the equipment be compact and simple. There is nothing more flexible for materials conveying than a pipe line, and no other means requires as little space.

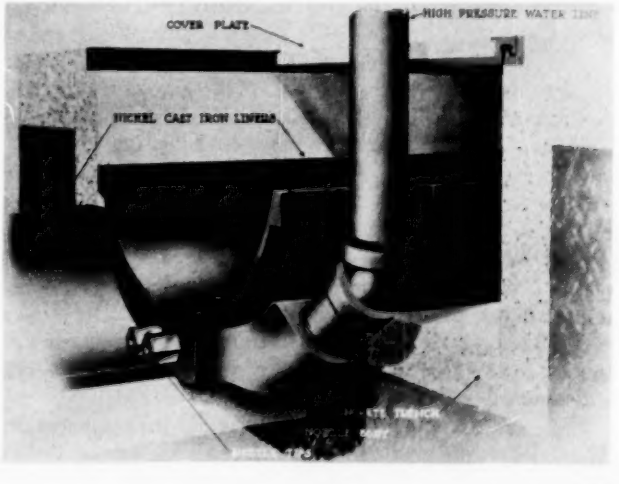
Figure 7 illustrates the space requirements for equipping an oxygen vessel with a pneumatic additive system (solid lines) and a mechanical additive system (dotted lines). This is not a hypothetical comparison; both system layouts were taken from actual proposal drawings for the same plant. It is quite obvious that tremendous savings in building costs and head room are achieved with the pneumatic system. The bins are kept low and can be placed at any convenient nearby place. The mechanical system, on the other hand, requires a building approximately twice as high. The first cost of a pneumatic system offers an extremely attractive advantage.

Pneumatic pressure systems offer steelmakers very accurate control of additives. Fingertip controls regulate both total weight and rate of introduction. High velocities of even the smallest particles assures material entering the metal bath. As the proportion of powder and coarse burnt lime is exceedingly hard to control, this is extremely important. (Weather conditions affect burnt lime: in damp weather the lime has a tendency to air slack, tending to develop fines.)

There has been some concern over the introduction of nitrogen into the steel via the conveying air. This has been carefully checked over an extended period. At no time has any trace of nitrogen been found.

Pneumatic handling of additives is not limited to the basic oxygen process. Other applications also offer worthwhile economies. In adding lime and limestone to electric furnaces, for example, economies in labor

Figure 8 — High pressure water is injected into the sluice underneath the material, and flows through nozzles cast integrally with the liner.



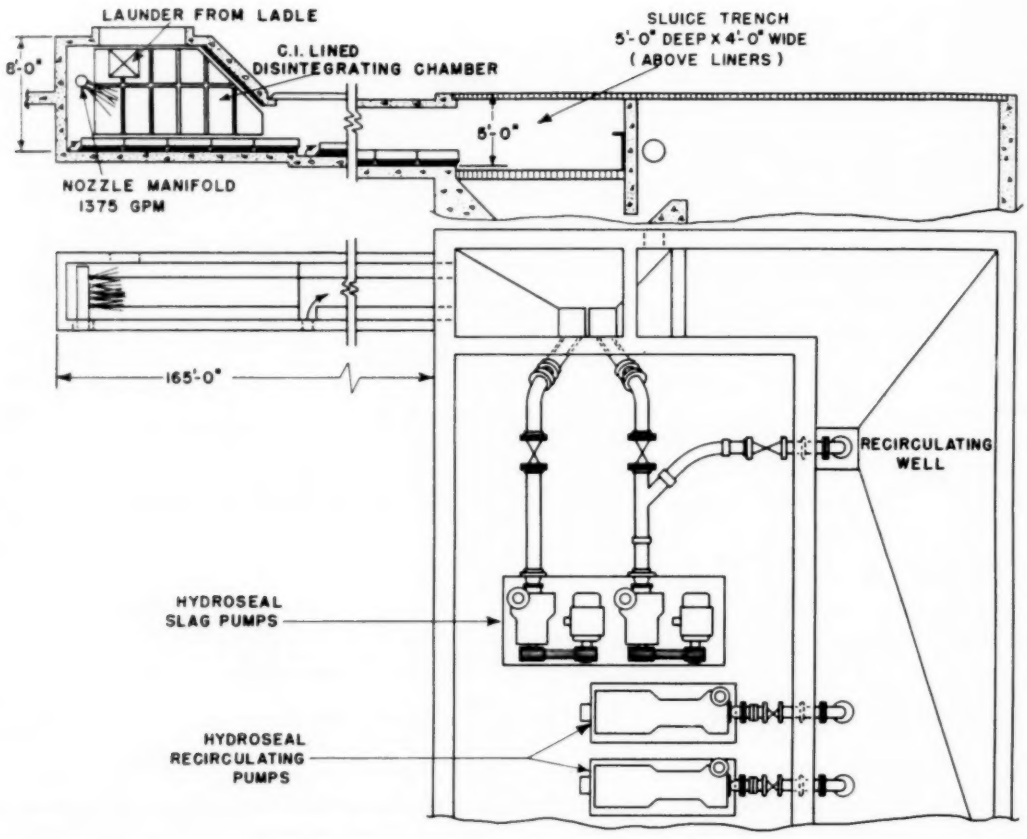


Figure 9 — Hydraulic slag disintegration and handling systems can handle the high volumes of slag produced as a result of increased usage of the basic oxygen process.

and low loss of heat can be accomplished by blowing the additive in through a small side opening. It is simple to do and the heat loss attendant in lifting the cover is eliminated.

Adding carbon to steel is another possibility which studies indicate a pneumatic system is adaptable. By using a pneumatic system it will be possible to use lower grades of anthracite dust. This is particularly adaptable to electric and open hearth furnaces.

HYDRAULIC ROLLING MILL SCALE HANDLING

Considerable work has been done in hydraulic conveying of rolling mill scales. These systems consist generally of high velocity sluiceways (pressures from 50 to 200 psig) for transporting scale from inaccessible undermill locations to a grab bucket sump. Long sluice runs are feasible under strip mills. A typical strip mill sluice is installed at the Weirton Steel Div. of National Steel Corp.

For blooming mills, where particles up to 1000 lb are handled, the runs must be short. A typical blooming mill scale sluice is located at McLouth Steel Corp.

Although not currently being done, it is perfectly feasible to pump sized scale to overhead dewatering bins and load directly into rail cars.

Flat high pressure sluices offer a number of advantages. The depth of pits, particularly in long runs, is materially reduced. Actually the liners of the sluice rise slightly, from nozzle to nozzle, to provide for the important water injection along the bottom of the sluice, underneath the material.

Figure 8 shows a typical liner with integral nozzle. These liners are staggered at intervals along the sluice. The nozzle is kept beneath the material flow. Turnbuckles are used to contract the liners for insertion in the trench. This type liner is typical for strip mill sluices. Larger and heavier liners, attached by different means, are required for blooming mill sluices.

DISINTEGRATING AND HANDLING OF METALLURGICAL SLAG

Hydraulic disintegration and handling of slag from metallurgical processes has been used for quite a number of years. The current practice of accelerating steelmaking by the use of oxygen in blast furnaces, open hearths and basic oxygen processes has increased the production of slag to an extent where fast, compact, high capacity slag handling systems become highly economic.

Figure 9 shows a slag handling and disintegrating system which has been in operation for over ten years. Slag is dropped into a disintegrating chamber where it is impinged on by a set of high pressure streams which break it up and quench it, reducing it to a readily handled size. The slag is transported through sluices to a sump and pumped away. In another system of this type, slag is disintegrated as it is discharged into a below grade storage pit equipped with a pump for intermittently disposing of the slag charges to fill.

Slag can also be disintegrated and sluiced directly to a pump pit from which it is pumped into overhead dewatering storage bins. Slag from these bins may be loaded directly into rail cars or trucks. Pumping long distances, five miles or more, is in many cases perfectly economic. Each case is a separate study.

Again, as in pneumatic systems, hydraulic systems are compact, simple and devoid of moving parts. ▲

Iron Ore Agglomeration—Sintering and Pelletizing

by ALAN ENGLISH,
Staff Engineer, Arthur G. McKee & Co., Cleveland, Ohio

THE rate at which any process develops is dependent upon the demand for the product, and sintering and pelletizing processes are no exceptions. The rapid development of these processes is due to the improved physical characteristics of beneficiated materials and lump ore when used in the blast furnace.

SINTERING PLANT

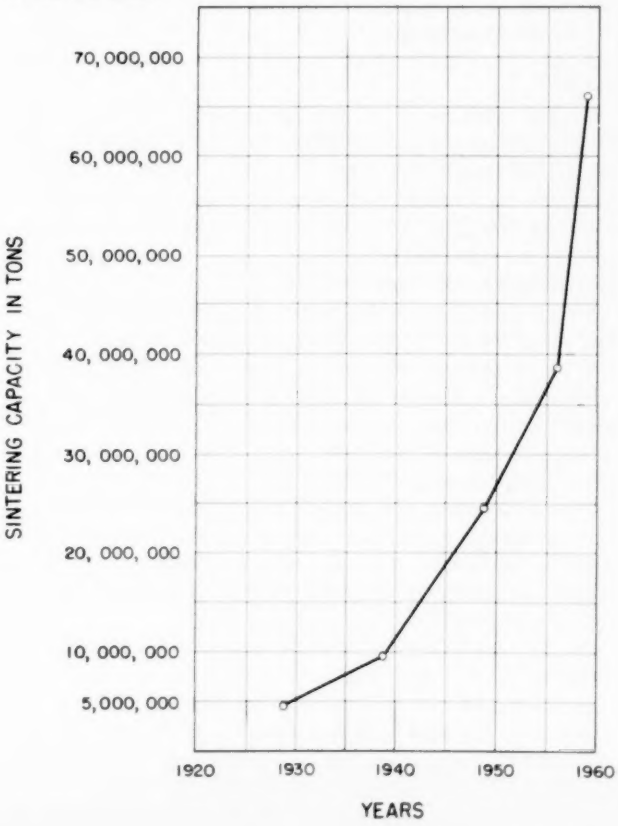
Handling facilities and raw materials—The raw-materials-handling facilities at most of the new sintering plants include a screening station of some magnitude, due to changes in raw materials used. The sintering plant is no longer limited to the use of flue-dust, iron-ore fines from U. S. mines and miscellaneous steel plant materials. Magnetite and hematite concentrates, iron ore from Venezuela, Peru, Brazil, Chile, Mexico and Northern Canada are some of the materials currently used. Screening of ores to provide coarse ore for direct charging to the blast furnaces, produces a large percentage of the fines for sintering.

Sintering plant production—Sintering is about 40 years older than pelletizing and obviously has undergone more development. M. F. Morgan recently reviewed the development of the sintering process over a 40-year period and some of his information is used for this review. Figure 1 shows the yearly capacity of sintering plants in the U. S. over a 40-year period. It is presently approaching 70,000,000 tons, which is almost triple the rated capacity of ten years ago. Unfortunately, a similar graphical presentation demonstrating the engineering effort associated with this development is not possible. It is obvious, however, that engineering contributions to this rapid increase in capacity were of great value. Some of these engineering features are discussed in the following paragraphs.

The increased sintering capacity was obtained by building larger plants equipped with larger machines. Of the 21 plants, either built or contracted for over this 10-year period, only three of the sintering machines were 72-in. wide; 15 were 96 to 99-in. wide; two were 144-in. wide and one was 157-in. wide. Obviously, plants are no longer rated at a nominal 2000 tons per day. The new standards appear to be 4000 to 8000 tons per day. The achievement of these large tonnages of production is perhaps the biggest development of the sintering process. Major changes in sintering-machine design preceded the advent of larger plants and engineering was required to resolve such questions as safe widths and lengths of the machine and other

Only time can tell whether pelletizing will displace sintering . . . . the most likely possibility is that each process will find a niche of its own.

Figure 1 — Sintering capacity from 1950 to 1956 increased by 60 per cent.



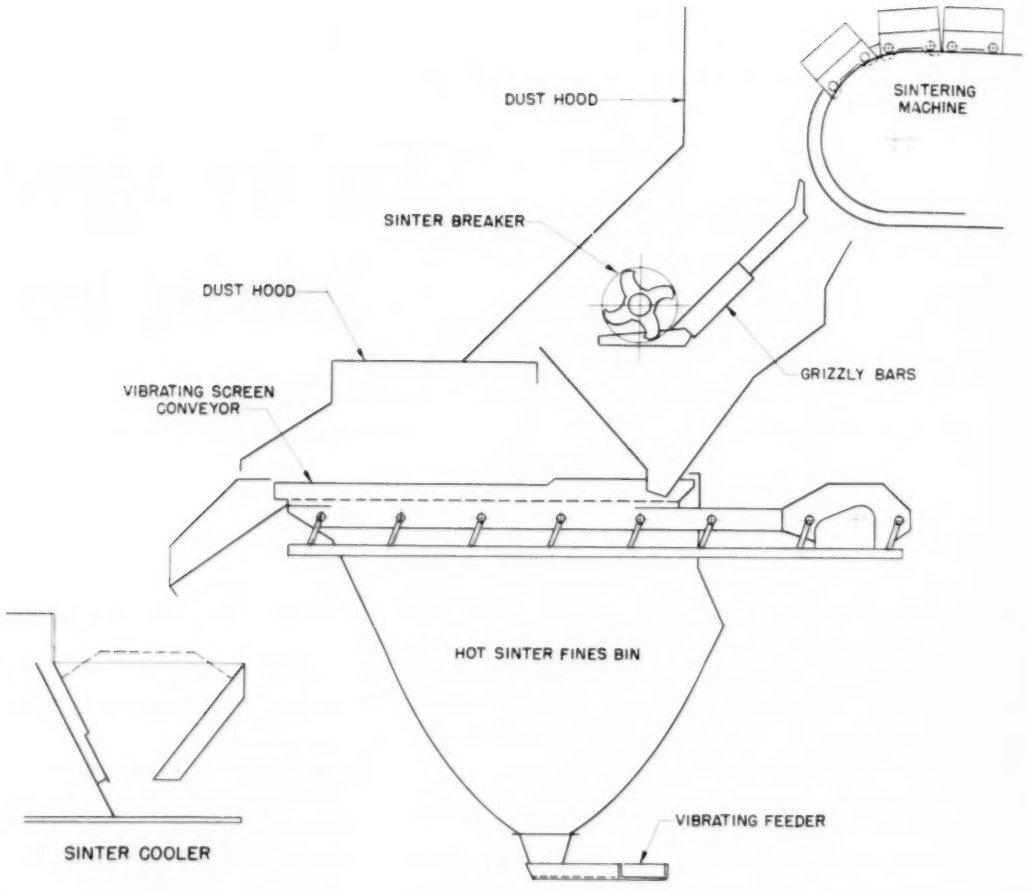


Figure 2 — The sinter must be sized and screened to get the right burden for proper blast furnace operation.

problems resulting from high-temperature operation. A few of the changes made in the development of an 8-ft machine were to increase the length of the pallets from 2 to 3½ ft and the depth of the pallet frame from five to ten in.; increase the diameter of the pallet wheels from five to eight in.; and completely redesign the wind boxes.

Major changes to auxiliary equipment were also made. For example, pug mills were designed to handle up to 300 tons of material per hr. Large drums and disk mixers were also designed, which, in some cases, replaced the pug mills. Research studies of the sintering techniques have indicated that a constant high permeability of the sintering mixture is essential. Greater attention must be given to the preparation of the sintering mixture if the increased production rates are to be maintained from these large sintering machines. The selection of mixing equipment to accomplish this purpose is, therefore, very important. The use of the swinging spout, which has been standard equipment in sintering plants for a few decades, was seriously questioned when the wider machines were installed. The swinging spout has proved satisfactory for an 8-ft-wide machine but the roll-type feeder, and other types, are being given preference for machines eight ft and more in width.

Sinter cooling—Air-cooled sinter was introduced more than ten years ago, but, since that time, major improvements in cooling equipment have been developed. It became apparent that the sinter should be of a reasonable size for efficient cooling and this led to crushing and screening the product at the discharge end of the machine. The procurement of sized sinter for cooling and handling purposes created a major engineering problem. Figure 2 shows one method of obtaining sized sinter for cooling. This method consists of crushing the sinter cake in a roll-type crusher as it leaves the machine. The undersize is collected in the hot-return fines bin and the oversize is fed to the cooler. With the advent of the 8-ft machine and the longer pallet, the capacity of the crusher and screen was increased to handle about 30 cu ft of sinter from one pallet instead of 12 cu ft, normally obtained from a 6-ft machine. The selection of materials for handling sinter averaging 1200 to 1400 F presented another problem. When this arrangement was first used, the crusher teeth and screen decks had to be replaced after about 2½ months of operation. An item which requires replacement after 2½ months of service in the steel industry would, under normal circumstances, be unsatisfactory but this represents a production of about 250,000 tons of sinter in large plants. To obtain this quantity of sinter, about 330,000 tons of material would have to pass through the crusher. This would represent about nine to ten months of operation on a 6-ft machine. Considering the physical characteristics of sinter, the wear on this equipment is very severe. Crusher teeth life of more than 2½ months is now possible and efforts are being made to further improve this performance.

Screening hot sinter was new to all screen manufacturers during the period of development and the ultimate specifications of a screen for this service were difficult to predict. Experience obtained from the operation of a 6-ft machine afforded no help in solving this problem. However, the sintering process is noted for quickly exposing all errors of judgment and engineering.

The first hot screen had to be completely rebuilt.

Sinter coolers originally were designed to operate on a natural draft basis and certain inadequacies were apparent. The larger sintering machines promoted the design and use of forced-draft or induced-draft coolers capable of cooling up to 6000 tons per day.

Sinter cooling provided a means of obtaining a separate hearth layer for the machines and also screened sinter for the blast furnaces.

Dust collection at the discharge end of the machine has been handled by mechanical-type dust collectors which have proved inadequate for the larger machines, and more consideration is now being given to wet-type dust-collecting equipment in an effort to alleviate dust conditions in the plant.

Plant control and sinter quality—Table feeders are still considered to be the most satisfactory method of feeding the various materials used in the sintering mixture; however, manual operation is being supplemented by automatic controls. They are arranged with conveyor belts to effect what is termed, "ratio proportioning of the sinter mixture." Figure 3 demonstrates the operation of ratio proportioning. The total quantity of ore is weighed and a desired quantity is maintained by a trimmer control arrangement, attached to two of the table feeders, which either increases or decreases the speed of the table in response to an impulse from the weighing mechanism. Each table feeder which feeds limestone, dolomite, flue dust, scale and solid fuel or any other additive, is equipped with individual weighing-conveyor belts. This arrangement provides for feeding the desired quantities of additives to the ore fines. The final control is to ratio the additives to the quantity of ore fines. Return fines can also be included in the ratio porportioning scheme, but there are still a number of operators who prefer to use a manual control for this purpose. The correct amount of water addition necessary to achieve the desired moisture content for good sintering is determined by the operator. After that determination has been made, the volume of water may be controlled automatically according to the weight of material being fed to the machine.

Automatic moisture control of the sintering mixture on a continuous basis has not been perfected up to the present time. Since the moisture content of the sintering mixture is one of the major factors in maintaining permeabilities of the sintering bed and in making good sinter, it is necessary to develop this control as soon as possible. Such a control has been designed, but it has not yet been tested in actual production.

Bed speed control works on the principle of measuring the resistance between electrodes, located in the sinter mixture in front of the cutoff plate, and has been used extensively on most of the new sintering plants. This method has proved very satisfactory but efforts to improve it are now being made.

A burn-through control has been designed to work in conjunction with the bed speed control. This works on the principle that the maximum temperature in the wind boxes indicates the point at which sintering is complete. Consequently, the burn-through control can be set to maintain the maximum temperature at the desired point along the sintering machine and computes the correction in feed rate to bring the burn-

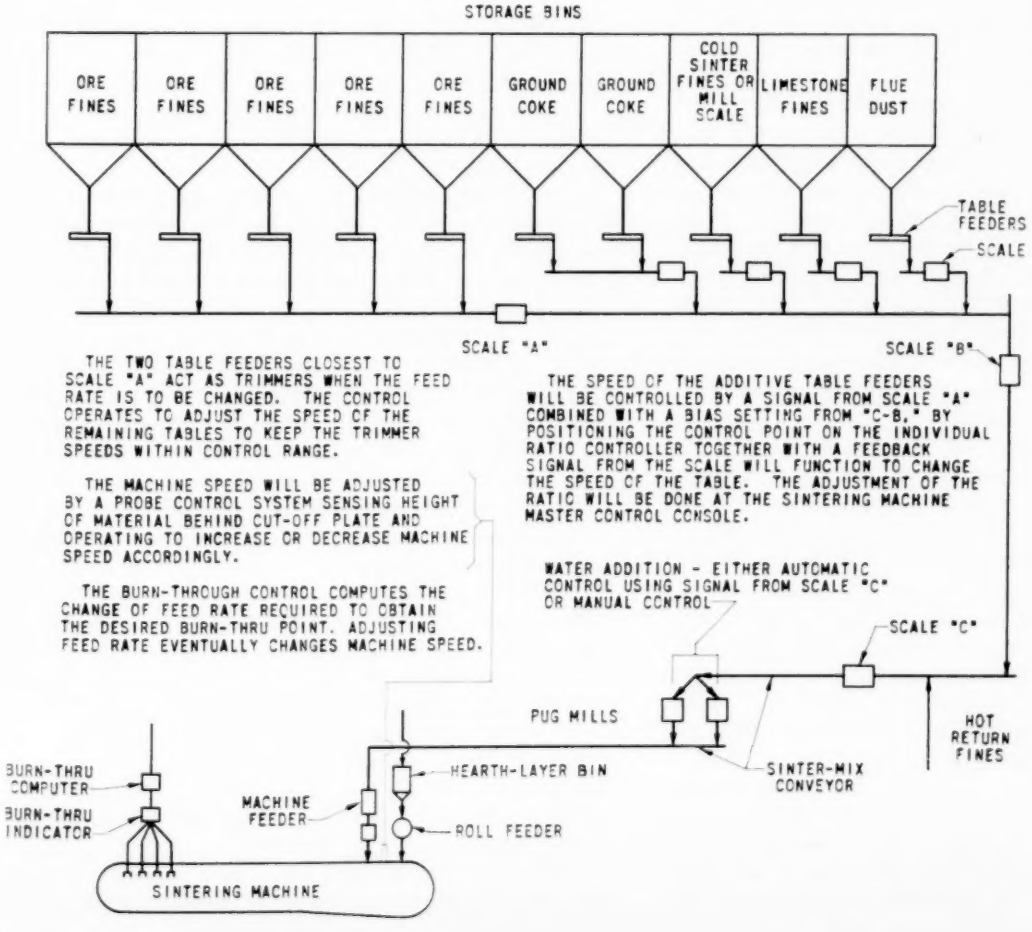

STORAGE BINS
ORE FINES
ORE FINES
ORE FINES
ORE FINES
ORE FINES
GROUND COKE
GROUND COKE
COLD SINTER FINES OR MILL SCALE
LIMESTONE FINES
FLUE DUST
TABLE FEEDERS
SCALE
SCALE "A"
SCALE "B"
THE TWO TABLE FEEDERS CLOSEST TO SCALE "A" ACT AS TRIMMERS WHEN THE FEED RATE IS TO BE CHANGED. THE CONTROL OPERATES TO ADJUST THE SPEED OF THE REMAINING TABLES TO KEEP THE TRIMMER SPEEDS WITHIN CONTROL RANGE.
THE SPEED OF THE ADDITIVE TABLE FEEDERS WILL BE CONTROLLED BY A SIGNAL FROM SCALE "A" COMBINED WITH A BIAS SETTING FROM "C-B," BY POSITIONING THE CONTROL POINT ON THE INDIVIDUAL RATIO CONTROLLER TOGETHER WITH A FEEDBACK SIGNAL FROM THE SCALE WILL FUNCTION TO CHANGE THE SPEED OF THE TABLE. THE ADJUSTMENT OF THE RATIO WILL BE DONE AT THE SINTERING MACHINE MASTER CONTROL CONSOLE.
THE MACHINE SPEED WILL BE ADJUSTED BY A PROBE CONTROL SYSTEM SENSING HEIGHT OF MATERIAL BEHIND CUT-OFF PLATE AND OPERATING TO INCREASE OR DECREASE MACHINE SPEED ACCORDINGLY.
THE BURN-THROUGH CONTROL COMPUTES THE CHANGE OF FEED RATE REQUIRED TO OBTAIN THE DESIRED BURN-THRU POINT. ADJUSTING FEED RATE EVENTUALLY CHANGES MACHINE SPEED.
WATER ADDITION - EITHER AUTOMATIC CONTROL USING SIGNAL FROM SCALE "C" OR MANUAL CONTROL
SCALE "C"
PUG MILLS
HOT RETURN FINES
BURN-THRU COMPUTER
BURN-THRU INDICATOR
MACHINE FEEDER
HEARTH-LAYER BIN
SINTER-MIX CONVEYOR
ROLL FEEDER
SINTERING MACHINE

Figure 3 — Automatic control of percentage additions results in easy control of the sintering process.

through to the preset requirements. The other controls, particularly those relating to the quantity of feed, then become effective. Although there are operating problems remaining to be solved, control of the process has developed to this degree.

The use of television has been tried for the purpose of relaying a picture, showing the condition of the sinter cake, as it leaves the machine, to the operating control panel. This requires considerable work before it can be used with confidence but efforts are being made to utilize as much modern equipment as possible. Instrumentation must be provided to make controls effective and understandable, and considerable improvement has been made.

Data logging systems are being considered for the sintering plants. This form of gathering information has been investigated thoroughly and will be installed in the near future by at least one major steel company.

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Some operators believe that strong sinter suits their requirements; some prefer to use a size index; some rely on the chemistry of sinter as the deciding factor; and others believe that sinter charged in layers of different sizes will promote good blast furnace operation. Tests for sinter quality are numerous and it is doubtful if any two companies use the same test. Self-fluxing sinter has received considerable attention within the last year or so, and considerable improvement in blast furnace performance has been reported by some companies. From an engineering point of view, the production of self-fluxing sinter presents no particular problem. However, the production of a desirable type of self-fluxing sinter may require that more attention be given to particle size of limestone to assure its proper dispersion in the sinter mixture; that dust-collecting facilities may have to be improved; that some changes to ignition may be necessary; and that additional ignition-furnace capacity may be needed to effect an over-firing operation. The biggest problem associated with the making of self-fluxing sinter in large machines may be in maintaining the temperature of the gases above the dew point at the main fan. Low temperatures at the fan invariably lead to fan problems resulting from the concentration of wet dust on the fan rotor.

Engineering affects cost of operation—Savings in operating costs can only result from a well engineered, well operated and well maintained plant. The costs of maintenance and repair labor and materials have a direct bearing upon the selection of equipment and materials.

Bearings are generally selected for 100,000-hr operation, conveyor equipment and belting for long life, grate bars for high-temperature operation, pallets for heat resisting wearing qualities and chutes and liners for their high-wearing qualities. Nevertheless, the sintering plant is still a high maintenance cost unit where preventive measures are most desirable in order to obtain lower total costs.

With the production of sinter at its present high level, there is an extreme shortage of coke breeze. Consideration is being given to the replacement of some of the solid fuel with relatively cheap gaseous fuel This is accomplished by burning gas in a large multiple compartment hood suspended over the sintering machine after the ignition furnace. Considerable work has been done in Europe on this phase of the sintering operation and experimental laboratory work conducted in this country has achieved results which warrant further investigation. This development work indicates that the physical and chemical characteristics of the sinter can also be controlled by using the over-firing technique.

PELLETIZING

Pelletizing has only been used commercially for about five or six years and is the newest of the agglomerating processes. Shaft furnaces and three types of grate machines, using a combination of updraft and downdraft techniques, are presently employed. A fifth method, called the grate-kiln system, is presently being installed on a commercial basis after two years of pilot plant work. As the name implies, the system employs a combination of both the horizontal grate and a rotary kiln. At the present time, all of the pelletizing facilities are located at the mine. An integrated plant for the production of pellets consists of the mine, crushing, concentrating and pelletizing equipment. The pelletizing plants, which currently use magnetite and hematite concentrates, are still considered to be in the early stages of development when compared to sintering.

The productive capacity of pelletizing facilities in the U. S. is presently about 15,000,000 net tons and is expected to exceed 25,000,000 tons within the next two or three years. Considering the fact that the rated sintering capacity only increased to about 25,000,000 tons after 30 years of development, and the fact that pelletizing uses finely divided materials, obtained by concentrating low grade ores, it would appear that pelletizing development will be at a much greater rate than sintering.

In reviewing some of the engineering problems presented by the pelletizing process, the following comments principally concern the downdraft grate method although some of the comments are applicable to the other processes.

About 5,000,000 tons of pellets per year are currently produced by the downdraft grate method on machines developed from the sintering machine. Perhaps the major development for future plants using the horizontal downdraft grate process will be machines designed specifically for pelletizing which have had no previous tie-up with sintering machines.

Pelletizing on a commercial basis achieved much higher temperatures than those indicated by any pilot-plant work, and consequently, the wind box arrangement is being designed for high-temperature operation. Figure 4 shows a cross section of the pelletizing machine now being considered. The ductwork is arranged to provide for minimum pressure drop. Dust collection between the ductwork and the fan is not provided and, although experience has indicated that this is still not necessary, extra effort is being made to mechanically remove dust and pellets that have fallen through the grate bars.

Pallets and grate bars have received considerable attention. High temperatures led to the use of a split

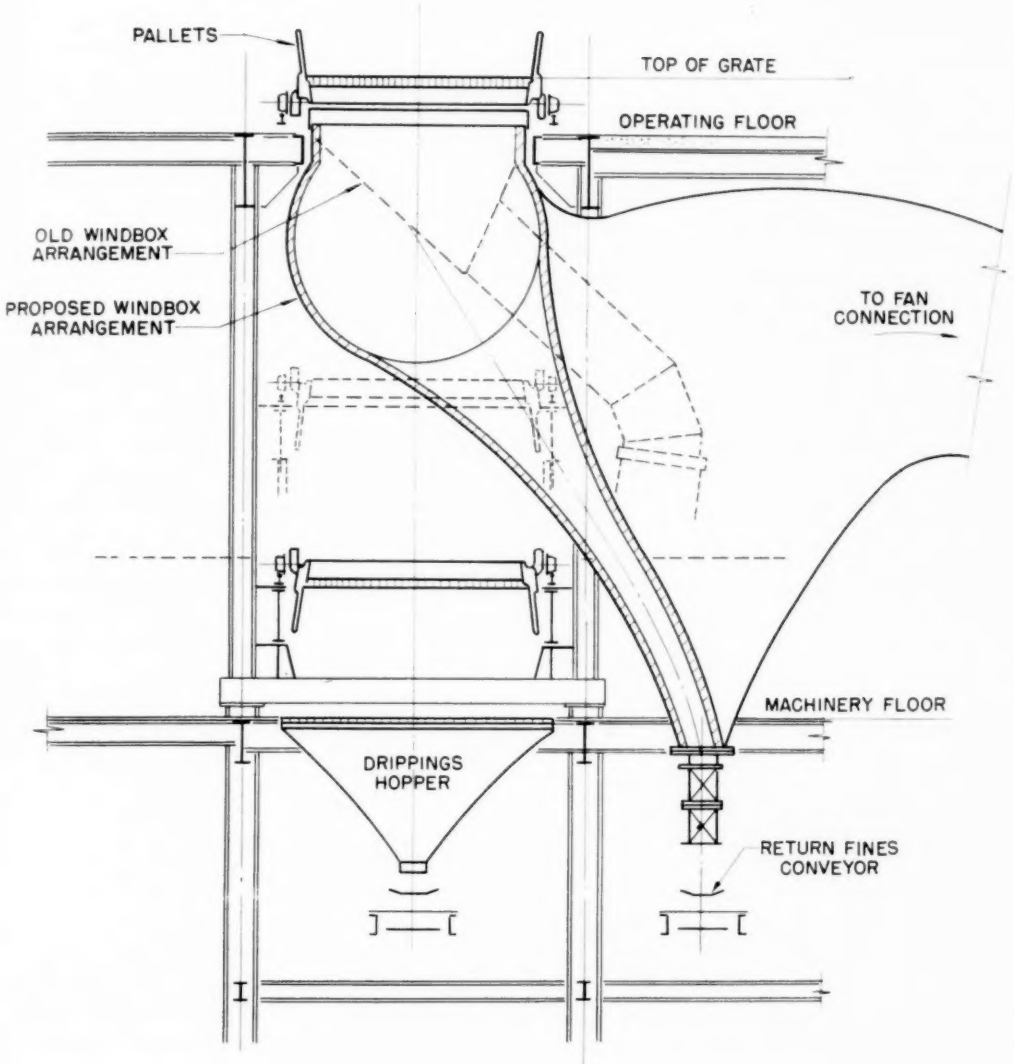

Figure 4 — A new style wind box is designed to promote an even flow of air through the bed of pellets.

pallet design to solve the problems resulting from expansion. Only high-quality alloy grate bars have been satisfactory for this operation.

The development of pelletizing is following the same pattern as sintering. Machines are presently available to produce between 2500 and 3200 tons of pellets per day, but designs for machines capable of producing about 5000 tons per day are being considered. The auxiliary equipment presents more of a problem. Balling equipment is extremely vital to the pelletizing process, since the productive rate of a pelletizing machine is directly related to the quality of the balls. At the present time it is preferable to use balling drums of known capacity rather than gamble with a smaller number of larger drums for the desired capacity. The available design data on balling drums are still limited.

Plant control and pellet quality—The control of the pelletizing operation starts at the mine and efforts should be made to provide a concentrate of desirable quality from which good balls can be made consistently in the pelletizing plant. Ordinarily, this requires a minimum variation in chemical and physical analyses of the concentrates.

Although relatively little is known about balling, there are two variables requiring considerable attention, the size and moisture content of the concentrates. These variables result from the concentrating operation and the type of ore being processed. In the balling operation the only readily adjustable controls are the speed of the drum and cutter bar. It has been found that the best built-in features of the balling drum are controls which can very accurately maintain a given speed and a supporting structure which is rigid and free from vibrations. Figure 5 shows a typical balling-drum circuit arrangement.

This arrangement includes provisions for adding bentonite. In all large commercial plants bentonite is being added to make a ball which is capable of being handled, dried and heated with a minimum amount of breakage. At the present time, no suitable substitute for this expensive additive is available.

If self-fluxing pellets are to be made, limestone or dolomite could be added at the same place and by the same method as the bentonite. However, additions with the incoming concentrates would be more desirable. The first large commercial plant using the horizontal downdraft method of pelletizing was equipped with a coal-adding or reroll drum, which, as the name implies, was for the purpose of rolling finely divided coal on the outside of the balls for use in the burning phase of the operation. Recent practice indicates that less solid fuel is necessary than was first indicated from pilot-plant work and this fuel can now be added either internally or externally, and the need for coal-coating

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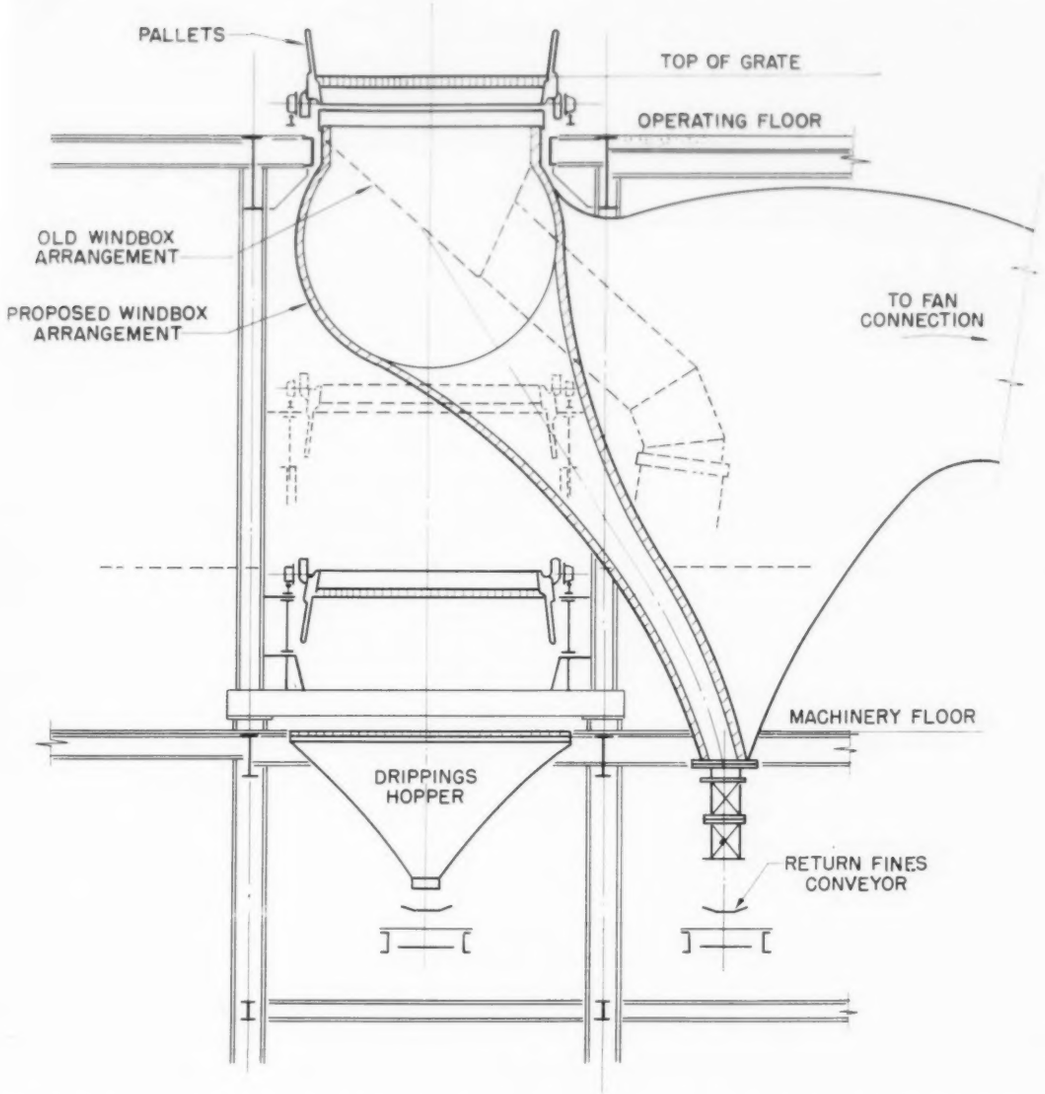

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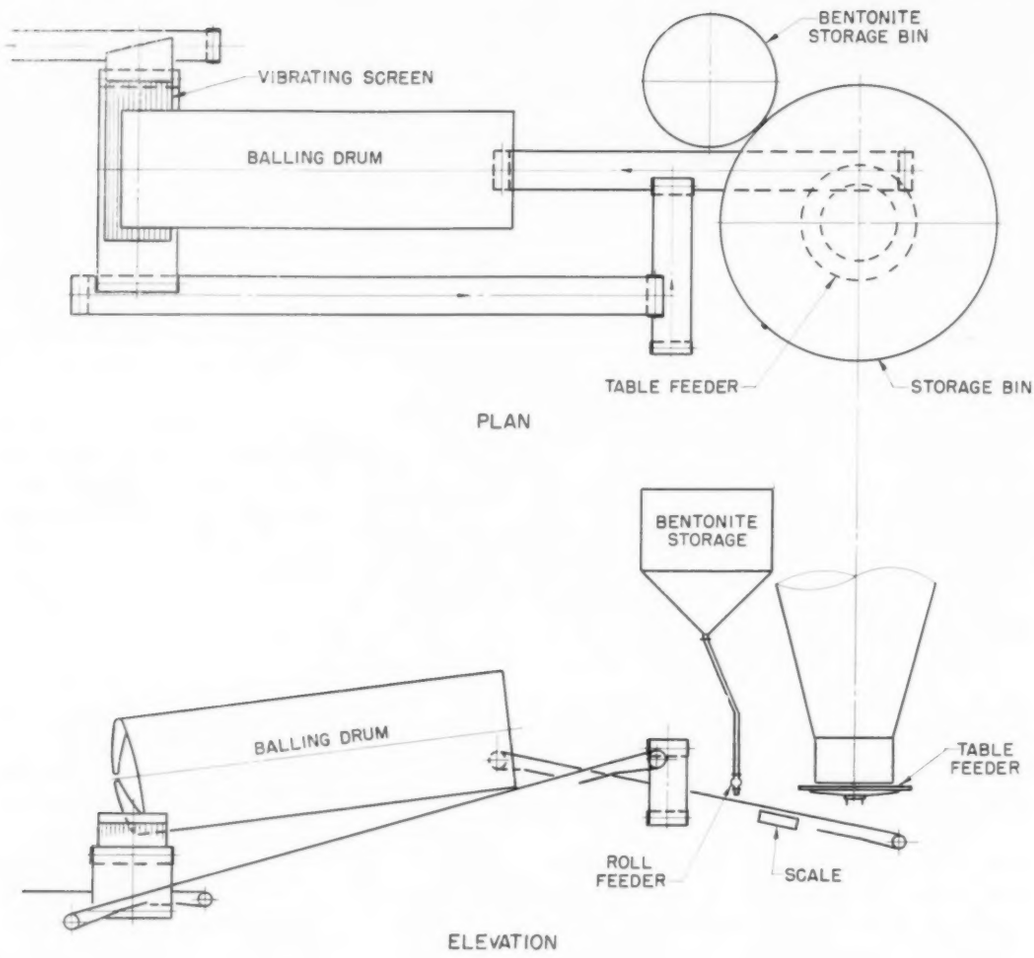


Figure 5 — Balling of the concentrates is the most important phase of the pelletizing operation.

drums may not be necessary.

Pelletizing on the downdraft machine consists of feeding the balls onto the grate as evenly as possible to a predetermined bed depth of about 14 to 15 in. and then treating the balls by updraft drying, downdraft drying, preheating, igniting, burning and cooling, either by downdraft or updraft. Updraft cooling is a recent development in the so-called downdraft pelletizing method. Recovery of sensible heat is very important, since large quantities of air are handled. Unfortunately, full use of the sensible heat is not possible, since tempering air must be used to avoid a temperature in excess of 900 F, which is the design limit of fans made from standard materials. Fans are available to handle much hotter air than this but it becomes a question of economics and, where one relatively cheap fan at 900 F can be used, probably five or six expensive fans would have to be used to handle air at 1100 to 1200 F.

Updraft drying is accomplished by using recovered air at a temperature of about 900 F. As much recovered air as possible is used for downdraft drying, preheating, ignition and burning at temperatures about 1000, 2000 and 2400 F, respectively. All the usual instruments and controls are used for this operation, for example, pressures in the furnace are automatically maintained and temperatures, pressures and air flows are recorded. Control of the rate of feed of concentrates and additives to the circuits was found to be absolutely essential in the pilot-plant stages. Consequently, commercial plants had this control built in.

More instrumentation and controls are used in pelletizing than were used for sintering in the early years. Since instrumentation and controls are relatively young, this is understandable. More development of controls for pelletizing will be accomplished in the future and, as in sintering, it is possible that television and data logging devices will soon be used to advantage.

The quality of pellets is normally determined by the results of the tumbler test. Other tests such as the drop test and compression tests have been conducted but only the tumbler test is used for plant control. This test consists of revolving 50 lb of plus $\frac{3}{8}$-in. pellets in the standard ASTM drum for 200 revolutions at the rate of 25 rpm, and then screening the product. The minus 10-mesh, 28-mesh or some other mesh size is used as the quality index. One company uses the 28-mesh fraction and a quality index of eight per cent is considered satisfactory. Pellets of this quality possess high resistance to degradation, producing a maximum of about four per cent fines during water and rail shipment to blast furnace plants located near lower lake ports.

SUMMARY

Blast furnace burdens of 100-per cent sinter are used by Appleby-Frodingham Steel Co. in England, Domnarvet Steel Works in Sweden and Magnitogorsk Metallurgical Combine in Russia with considerable success. Large scale blast furnace tests, using 100-per cent sinter burdens and also 100-per cent beneficiated burdens have also been conducted in this country with exceptional results. It now appears that sinter

will constitute a major proportion of the future burdens in our blast furnaces. Large percentages of pellets have been used in the blast furnace burdens in this country by most major steel companies with apparent success but detailed statistics on blast furnace performance have not been published to date.

Because the sintering process is flexible and can use a large variety of materials and because pelletizing has been developed to use very finely divided material, there appears to be a definite place for both methods of agglomeration. The replacement of one process by the other seems improbable; however, due to the availability of both of these processes, considerable evaluation will be made before a process is selected for a specific material.

The trend is definitely toward the development of a fully automatic sintering plant. This development will be successful, providing it is possible to try individual controls and equipment first before making a composite arrangement. The most important control necessary for the sintering process is one to regulate the moisture content of the sinter mix. When this is accomplished, a fully automatic sintering plant will definitely be in sight.

Pelletizing appears to be approaching the same goal that has been achieved for sintering. Self-fluxing pellets have not been made on a commercial basis yet, but the trends of the industry indicate that this may be the next stage of progress. No engineering problems exist in making provisions for this undertaking, but weathering and handling are problems which can be predicted. Metallurgically, the primary difficulty will be to maintain the lime content in solution, since any free lime will reduce the pellet strength, primarily due to weathering.

It has been mentioned that data logging is being included in the agglomerating plants. No process benefits are claimed from the use of a data logging system. However, the collected data are in a more composite and usable form. By the use of these data the physical and chemical characteristics of sinter and pellets, particularly sinter, may be maintained more consistently than at the present time and blast furnace performance may be influenced to a considerable degree.

In the progress toward greater use of instrumentation and control in agglomerating plants, it must be realized that a different type of labor is necessary than is presently used. Instrument mechanics and control engineers must be considered as a necessary part of the operating crew if high-operating efficiencies are to be obtained in these plants. ▲

Agglomeration of Iron Ore Furthers Automation of the Blast Furnace

by DR. M. J. GREAVES, Chief Engineer, Metals Div., Arthur G. McKee & Co., Cleveland, Ohio

Developments in sintering and pelletizing in the past decade have directed attention to blast furnace automation—thus outlining a problem which may possibly only be solved by reappraisal of existing blast furnace plant design

DURING the last few years larger quantities of sinter and pellets, some containing added fluxes, have become available as blast furnace burden materials. New techniques, developed concurrently with the increased use of these beneficiated burdens, have made possible lower coke rates and substantial increases in blast furnace production.

Principal changes in blast furnace practice include:

1. Beneficiation of raw materials.
2. Use of self-fluxing sinter.
3. Operation at high top pressure.
4. Use of higher blast temperatures.
5. Additions of moisture, oxygen and natural gas to the blast.

These significant developments warrant a re-examination of the problems involved in blast furnace plant design.

A conventional blast furnace plant by almost any measure is a dependable and efficient operation. Any new designs must be judged in terms of what can be done with existing facilities.

One area which is receiving increased attention is automation. For years we have had these automatic features:

1. Stove dome temperature control.
2. Hot blast temperature control.
3. Hot blast moisture control.
4. Tuyere proportioning.
5. Top pressure control.
6. Coke screening, measuring and charging.
7. Water measuring and charging.
8. Skip hoist speed control.
9. Distributor control.
10. Large and small bell control
11. Test rod control.

To justify further automation of a blast furnace plant, some economic or other advantage must be shown. It will be difficult to improve the availability of a plant which is already capable of producing iron about 98 per cent of the time over a campaign of several years. Certainly no savings in capital costs can be expected. In fact, automation inevitably increases the initial cost of a plant.

Therefore, incentives to automate must be found in reduced operating costs, increased production, higher-quality output and more efficient working and safety conditions. Vital as these incentives are, automation must come to terms with the fact that the blast furnace process is inherently intermittent. These factors are especially pertinent:

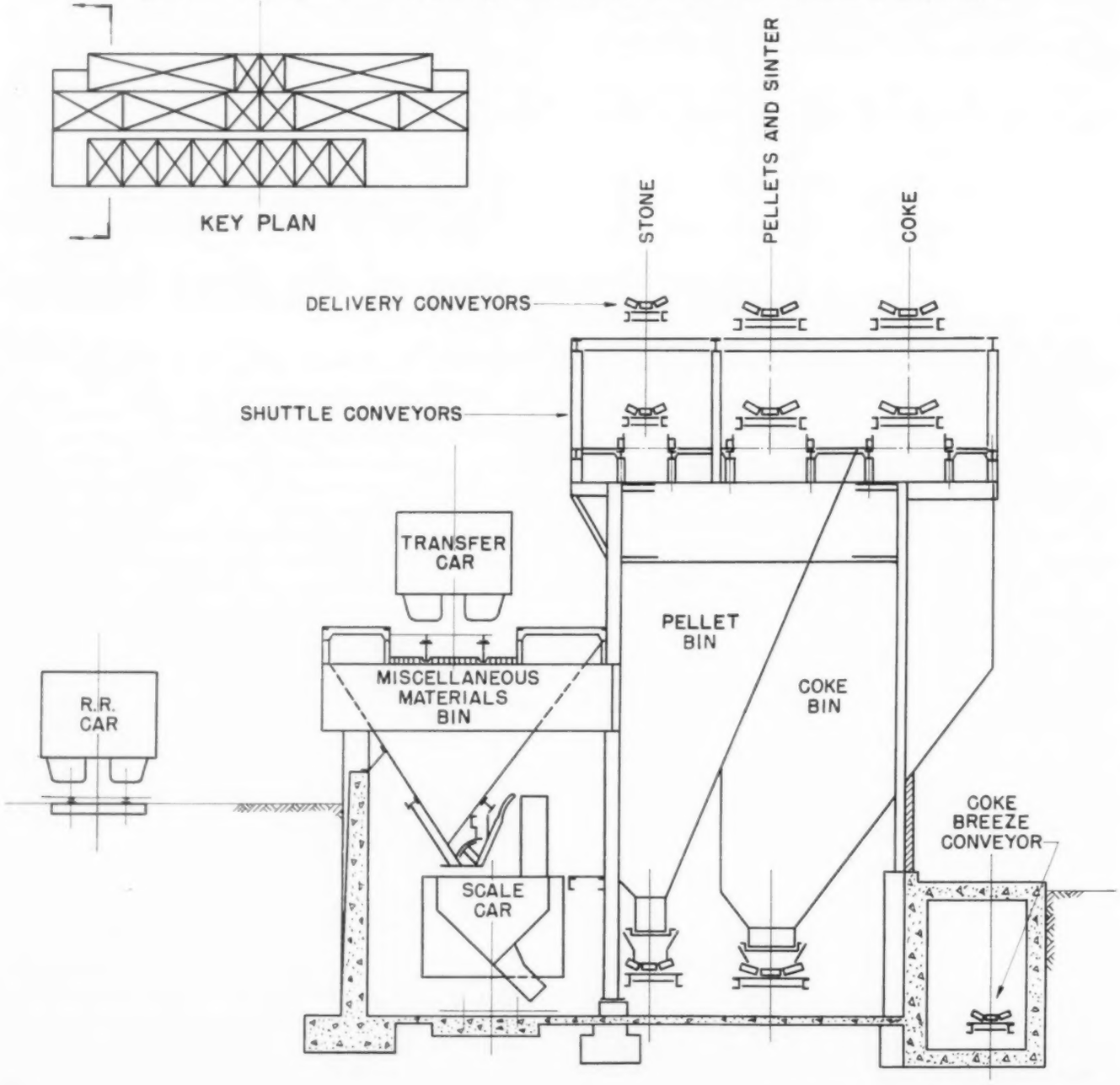
1. Hot blast is heated in recuperative stoves.
2. The furnace is filled by skip cars and sealed by one or more bells.
3. Hot metal and slag are withdrawn intermittently.
4. Materials may vary considerably in chemical and physical properties from hour to hour.
5. Ores, in particular, are not free flowing, and thus are difficult to handle.

An example of recent improvement in blast furnace technology is the use of automatic stove-changing facilities.

Increased demands for more wind and higher temperatures can be met in a number of ways, including higher dome and stack temperatures, operation of stoves in parallel and the use of more and larger stoves. Also, significant improvement can be made by shorter stove cycles, but these require power-operated valves and control equipment to reduce the stove-changing time.

A selector switch on the pyrometer panel enables the operator to set the desired program, such as temperature or time cycle. The stove change is initiated by pushing a start-sequence button. Annunciator-type indicating lights are used to show the positions of the various valves. The lights come on consecutively as the sequence progresses. The pyrometer panel also includes recorder controllers for dome temperatures, stack temperatures and gas flow. As a safety measure, ignition temperatures are automatically checked prior to placing a stove on gas. A memory-type annunciator system is provided to facilitate trouble shooting.

Figure 1 — In this stockhouse all principal materials can be handled automatically by conveyors.



THE AUTOMATIC STOCKHOUSE

Perhaps the best example of the influence of agglomerates on blast furnace design is to be found in the stockhouse, where flexibility is required to accommodate a wide variety of beneficiated materials.

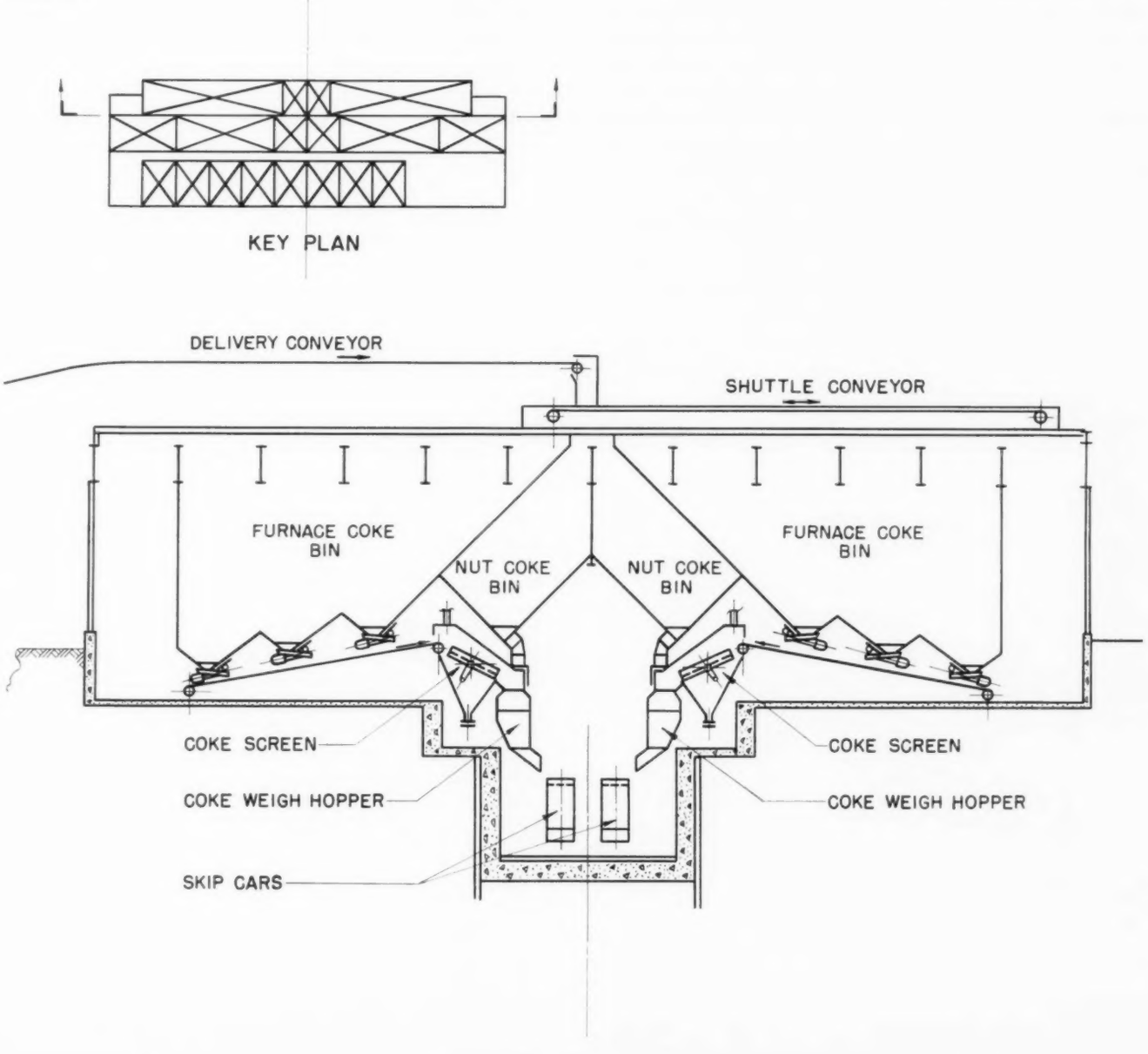
The conventional stockhouse consists of a series of bins for each of the materials that must be handled. A scale car is used to draw materials off the bottom of the bins and deliver them to the skip buckets in the skip pit. Coke because of its free-flowing nature and the large quantities required, has been handled automatically for many years by means of feeders and conveyor belts. An automatic stockhouse carries this arrangement one step further to include other materials which are free flowing, such as sinter, pellets and some screened ores.

These materials are highly variable in nature. Coke, for instance, is light and should be handled gently, hence the coke bins should be designed to hold breakage of material to a minimum. At the other extreme, the stockhouse should be designed to handle earthy clay-containing ores which are difficult to get out of the bins. These materials have a vital bearing on efficient stockhouse design.

For illustration of the problems to be met in stockhouse design, it might be well to consider the materials that must be handled in one day to support an iron production of 3000 tons. The quantities of raw materials will depend importantly on the chemical content of the furnace burden and the coke rate. A good practice might require about 2000 tons of coke, 1000 tons of stone and 5000 tons of iron-bearing material.

The average rate at which these materials must be handled is approximately 320 tons per hr. To realize this average, delays and the need to catch up must be

Figure 2 — Automatic operation is achieved through the use of conveyors which keep the bins full and weigh hoppers which are filled to a predetermined weight. These hoppers are filled and emptied automatically as coke is called for by the operator.



AUTOMATIC STOCKHOUSE

taken into account. This means that the materials-handling system must be designed for a rate of 500 tons per hr or more. The materials must be carefully weighed or measured volumetrically before they are charged into the furnace.

Musts for stockhouse design—Essential characteristics of successful stockhouse design are threefold: they must provide a continuous accord of serviceability, flexibility and dependability.

A primary need of the serviceable stockhouse is flexibility to handle special situations which may arise beyond anticipated requirements. Whereas some industrial equipment quickly becomes obsolete and must be replaced within a few years, a stockhouse is expected to last 40 or 50 years. During this time the furnace it serves may be rebuilt and enlarged several times, and the nature of the materials to be handled may have changed considerably from what could reasonably have been anticipated at the time of the original construction. The well-planned stockhouse must be equipped to meet such altered situations.

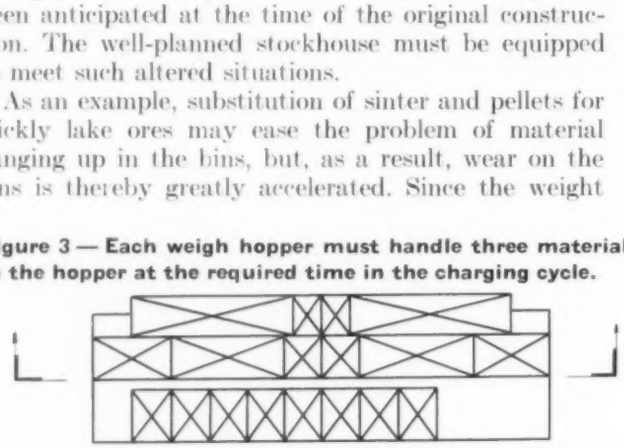
As an example, substitution of sinter and pellets for stickly lake ores may ease the problem of material hanging up in the bins, but, as a result, wear on the bins is thereby greatly accelerated. Since the weight per cu ft of sinter is less than that of ore, a larger volume of material must be handled to support the production of a furnace. If the use of agglomerates results in increased production, the need for additional capacity may be still further increased.

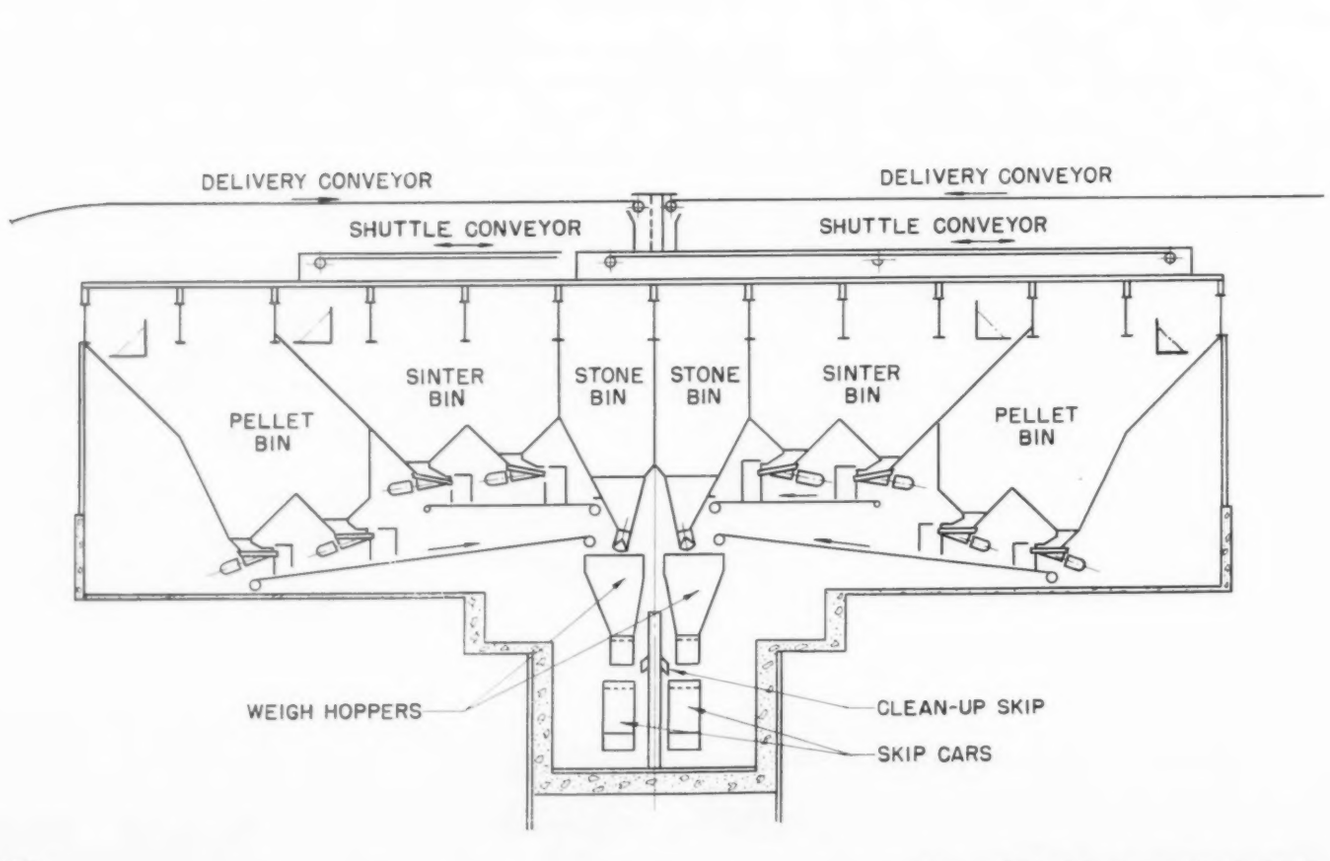
If, on the other hand, a stockhouse is designed to handle only pellets and sinter and no provision is made for sticky ores, a completely unworkable arrangement may result. Furnaces have had to be operated at times on available material regardless of their physical characteristics.

In stockhouse planning, close attention must be given to the design of the bottom of the material bins because this point can become a serious bottleneck. Unless the materials are such that they can be freed from the bin in a dependable fashion, full automation of this function for all materials does not appear to be practical. For sticky ores, no one has yet devised an acceptable substitute for a manually-operated gate and a scale-car operator who can coax the material out of the bin with the aid of a vibrator, bars and hammers. These nonautomatic features, however annoying, may still serve a vital purpose and their elimination might cause the entire operation to fail.

Most blast furnace plants have some provision for

Figure 3 — Each weigh hopper must handle three materials and the controls must be such that the proper material is in the hopper at the required time in the charging cycle.





charging iron or steel scrap of various kinds. Such scrap is unsuited for handling on an unattended rubber conveyor belt. Therefore, if there is no scale car, the bins for this material probably should be located at the center, where scrap can be dropped directly into the skip tub.

In locations where the winters are severe, provisions must be made to permit continuous operations during periods of extremely cold weather.

Figure 1 shows a cross section through the material bins of an automatic stockhouse. It is called an automatic stockhouse because all of the principal materials for charging the blast furnace can be handled automatically by conveyors. Three delivery and three shuttle conveyors are provided to fill the bins with stone, pellets, sinter and coke.

The bins on the right are for coke. The bins through the center are for pellets, sinter and stone. Three of these bins are located on each side of the center line arranged in a symmetrical fashion with the stone bins located over the skip pit.

On the left side is shown the conventional stockhouse filling equipment. A railroad car or transfer car can be used for filling a number of bins with whatever material it may be desirable to handle without passing through the automatic stockhouse. This facility would be used for sticky ores as well as for other materials, such as scrap, open hearth slag, roll scale, dolomite or gravel. In an emergency, operations could continue by filling the skip cars with the conventional scale car and related facilities, but possibly at a reduced wind rate.

Figure 2 shows a longitudinal section through the coke bins. Two nut coke bins are located at the center where coke is discharged directly into the weigh hoppers without intermediate handling. Nut coke may be charged from these bins in sequence with other materials. In an emergency all coke could be brought in these bins, by-passing the screens, belts and feeders.

The furnace coke bins are located symmetrically on either side of the nut coke bins. The furnace coke bins are shaped as shown so that the bins can be filled without dropping the coke an unnecessary distance and incurring undue breakage. The bins are filled from the center outward by means of a shuttle conveyor which moves along, as the top of the pile builds up, forming a slope approximating that of the bottom of the bin.

The two hoppers shown in Figure 2 are supported by a weighing mechanism and are normally kept filled with a predetermined amount of coke, which may be about 300 cu ft, depending on the size of the skip tub. At the appropriate time in the charging cycle the coke is automatically discharged into the skip car. The gate is closed when the hopper is emptied, as determined by weight. A limit switch on the gate operator starts the sequence of operations which refills the coke weigh hopper. The screen is started first, then a belt, and finally, the coke feeders. An anticipatory control stops the feeders and belt when the weigh hopper is nearly full. The screen is allowed to continue running, to clear itself for the next cycle. All of this must be done during the time in which the skip car goes to the top of the furnace, dumps and returns, because the program may call for two consecutive coke charges into this skip. Round-trip time varies, but is generally under two min.

Figure 3 shows a longitudinal section of the material bins in an automatic stockhouse. The material is brought in by delivery conveyors to a centrally-located transfer point from which a shuttle conveyor distributes the material to the proper bins. These bins are shaped like coke bins to hold down materials breakage.

Since each weigh hopper must handle three different materials, the automatic charging control must cause the hopper to be filled with the proper material so that it will be ready when needed. At the appropriate time in the charging cycle the material is automatically discharged into the waiting skip car. The operation then proceeds in a fashion similar to that for coke.

Figure 4 shows a cross section of the automatic stockhouse taken through the skip pit. The skip car shown at the bottom of the pit can be filled by gravity from the scale car or by either of two weigh hoppers. This arrangement with conventional facilities backing up the automatic stockhouse provides the operator with considerable flexibility. The coke breeze is taken from the screens and removed by conveyor, since this material is not wanted in the blast furnace.

A successful blast furnace operation hinges crucially on the ability of the operators to keep the furnace full. This applies especially where the blast furnace may be one unit in an integrated steel plant and a steady and dependable production of iron is necessary. Any disruption in the process is felt throughout the plant, with a consequent serious loss of production.

The blast furnace is a costly facility subject to a great many hazards. The furnace operation involves a delicate balance of many variables, and it is necessary that the stockhouse be available at all times to keep the furnace filled with the proper materials when and as required. The effects of an error or delay in the charge might upset the furnace and disrupt the operation for several days.

Data logging and automatic charging control—Automatic charging control is in use today on a number of furnaces. On some recent installations the desired sequence is obtained by pressing buttons on the charging control panel. These buttons set up the order in which the ore, coke and limestone can be fed into the skip car. On other installations a panel is provided with selector switches by which a supervisor can quickly setup or change the entire sequence.

Programming also can be accomplished through the use of prepunched accounting cards. An automatic data logging system could be used with either type of programming system to obtain a permanent record of blast furnace operations. Such records would facilitate accounting procedures and the correlation of blast furnace performance with actual practice.

Today the industry is considering relatively simple data logging and independent programming systems. After experience is gained, these systems will be extended to increase the amount of data logged and to include more sophisticated methods of data processing. This second phase, in turn, will be followed by incorporation of computers for calculating performance and operating parameters. In the final phase, the computed information will be used to re-program and control the process automatically and to program subsequent processes.

Before the blast furnace process can be fully automated it will be necessary to eliminate large variations

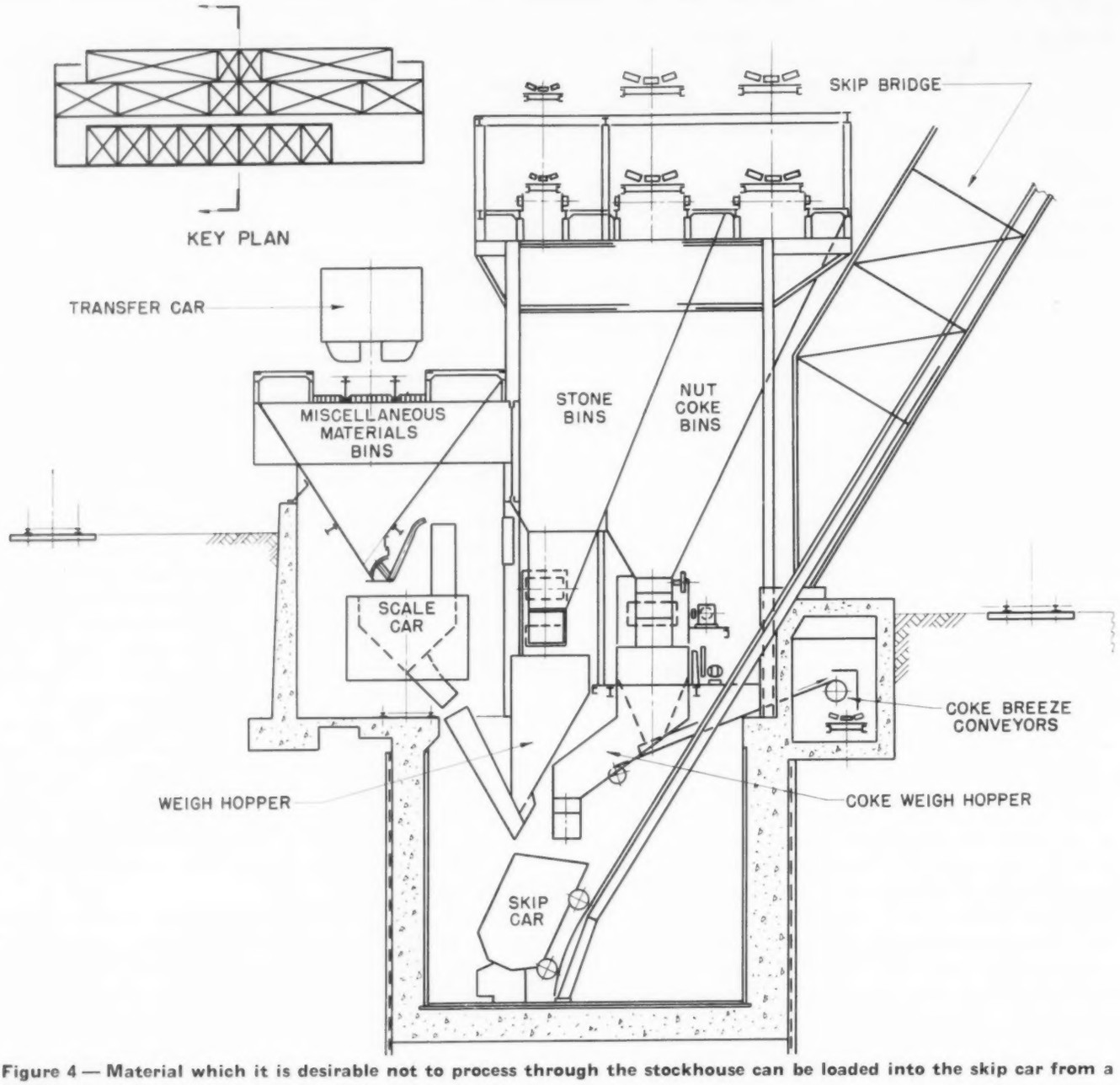


Figure 4 — Material which it is desirable not to process through the stockhouse can be loaded into the skip car from a scale car.

in burden materials, possibly by means of a bedding system. Alternatively, some means must be found for continuously determining the chemical and physical characteristics of the materials which are charged into the blast furnace. This may require an elaborate sampling system in which a small fraction of the charging material is diverted to a sampling circuit.

This sample, of course, must be taken in such a way that it is truly representative of the material being sampled. For example, a continuous size analysis might be obtained by a multiple-sieve arrangement in which the stream is divided into several fractions and the weight of each fraction determined on a continuous basis. To determine the chemical analysis it would be necessary to crush and divide the sample to obtain a portion suitable for continuous analysis.

The blast furnace will never be truly automated until some form of automation is applied to the cast house. It would be presumptuous of anyone to predict at this time what form this automation will take. However, it is believed that time and labor saving devices can be provided to handle adequately all of the hot metal and slag that a furnace can produce. Some consideration is being given to a second iron notch, but the need has not been fully demonstrated.

SUMMARY

Developments in the agglomeration of iron ores have made possible lower coke rates and substantial increases in blast furnace production, focusing attention on blast furnace automation.

The use of conventional facilities of proved dependability backing up the automatic features of the stockhouse provides considerable flexibility, to accommodate a wide variety of materials, and to meet changing conditions that alter anticipated requirements.

Before the blast furnace can be fully automated it will be necessary to eliminate or monitor large variations in burden materials and to apply some form of automation to the cast house. ▲

Development of a Machine Shop Tool Program

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The continual demand for larger and larger products with lower and lower tolerances necessitates a continuous, well planned and properly executed modernization program for the machine shop

THE economic stability of a company is dependent largely upon the condition of its facilities. A continuous program is necessary if it wishes to retain its position in the industry. New and modern tools must be added and old facilities must be modernized or discarded. This is the kind of thinking that has made us proud of the five machine shops in the manufacturing division of Bethlehem Steel Co. The changes are unbelievable: the largest shop, Figure 1, was built in 1890. It is 0.3 mile long and covers ten acres of floor space. It was equipped with the finest machine tools available at the time, Figure 2. Machines built during this period were driven through a series of overhead line shafts and belts which were motivated by steam engines. The machines were slow and lacked the anti-friction bearings of today, as well as the smooth running gears, the power traverse, the measuring equipment and all the other mechanical and safety features of the present-day machine. Many changes were made to these machine tools from year to year. They were slowly improved and when carbide cutting tools were introduced a complete modernization program became necessary. Belt driven machines became obsolete, overhead lineshafts disappeared and individually powered machine tools of the latest design became necessary.

At the close of World War II, a complete study was made of all facilities in each department so as to enable the department to recommend an improvement program. Consideration was given to items deemed most necessary and desirable for the maintenance and improvement of the operation. Full and substantiating data had to be obtained on all of the equipment involved giving consideration to the following:

1. Safety and welfare.
2. Replacements necessary to machine forgings made from 134-in. ingots which weigh 750,000 lb.
3. Items which will improve production, quality and cost to keep pace with economic growth, to meet competition and to yield a reasonable return on the investment.

This data together with a tabulation of the approximate cost and the expected annual savings accompanied the proposed program to the plant engineering department, which was assigned to integrate the entire program.

The department completed the necessary engineering, determined the sequence of the items presented and deleted the items which for various reasons should not be considered at that time. Some were abandoned altogether. After final analysis by the engineering department the program which was endorsed by the operating department was then presented to top management for final approval and the necessary appropriation.

The machine tool development program at Bethlehem Steel Co. has enabled the shops to be known as among the finest in the entire industry. Shop appearance has continued to change so that equipment is now available to machine the smallest component parts for machinery as well as the largest flange shafts for hydroelectric units requiring a lathe which will swing 147-in. diam stock. New and modern machine tools purchased in the last ten years have cost approximately $12,000,000. An additional $2,500,000 was spent on modernizing some of the old machine tools. These expenditures have resulted in increased production from 30 per cent on some products up to 200 per cent on others. What are some of the improvements made in the last ten years?

Since about 90 per cent of forged products must be bored, we sought and found a faster and cheaper boring method known as trepanning. Experimental work

Figure 1 — The No. 2 machine shop is shown as it was in 1918. Built in 1890 it has been modernized and improved through the years.

Figure 2 — A 110-in. lathe in use in the shop for 58 years was scrapped as part of the modernization program. Notice the overhead belt drive for the headstock.

Figure 3 — Solid boring heads of this type were replaced by trepanning heads which cut only a cylindrical groove, permitting removal of the center as one piece.

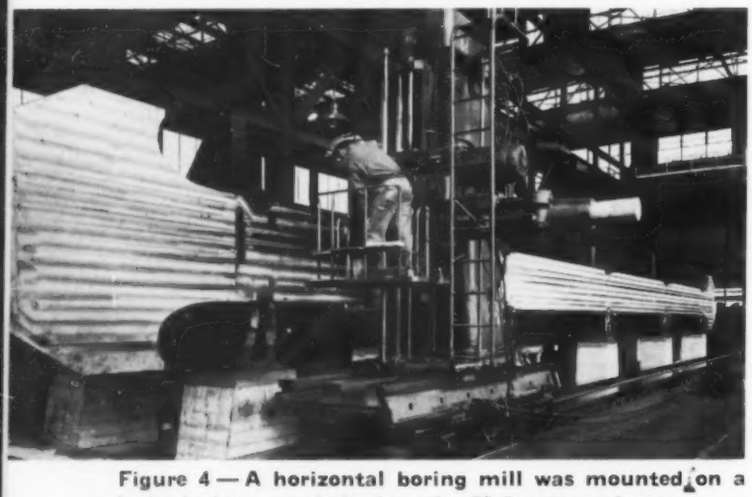


Figure 4 — A horizontal boring mill was mounted on a lathe bed to permit boring of a 70-ft press column.

Figure 5 — Allowable feed of the trepanning head using carbide inserts is up to ten times faster than previous methods.

was started in 1949 and a year later we were in limited production boring Army 90 mm guns.

A 14-in. solid boring head of the type used before this method was developed, Figure 3, was only able to bore at the rate of approximately 3½ in. per hr. The new style boring heads for the same size hole are made up of six high-speed cutters which cut around the axis of the forging thus eliminating the center cutter pressure. The cutters now cut free in a clean shearing action enabling an increase in the feed from 3½ to 18 in. per hr.

Figure 4 shows the start of a boring operation boring a 16⅝-in. diam hole through a large column. The core was 12½ in. diam.

Figure 5 shows the first machine converted for carbide trepanning. A conventional single end boring lathe of 1940 vintage was used. The original hp was increased from 25 to 50 hp in the headstock drive. A 35-hp coolant pump was installed and the feed range was increased from 3 to 14 in. per min and the top speed was increased from 150 to 600 rpm. Today there are two machines of the same vintage which have top speeds of 1300 rpm. This is the control end of the trepanning machine, Figure 5, and the operator must watch the machine's action with regard to hp, feed and speed meters and the chip formation, all of which are visible from this location. Seven boring lathes of this type have been converted.

We have recently completed rebuilding the 110-in. boring lathe, Figure 6, for trepanning. The headstock speed has been increased from 16 to 175 rpm. A new revolving bar driver was built to our specifications with speeds up to 600 rpm enabling it to handle our heaviest type forgings requiring a small bore; it is not feasible to rotate these forgings using headstock speeds alone. The necessary speed for carbide boring is now obtained by bar rotation in addition to the permitted headstock speed.

Our many horizontal boring mills, 11 of which are of the latest design, together with some which have been reconditioned, range in size from a 3-in. spindle diameter up to our latest 10-in. spindle size. Figure 7 shows the newest member of the horizontal boring mill family: a 10-in. spindle size and the largest machine tool of its type used anywhere in the industry. Bethlehem Steel Co. worked with the manufacturer for several years designing this machine to suit the needs of its jobbing shop. The machine weighs approximately 200 tons and is 27 ft from floor level. It has a 12-ft vertical and horizontal travel and a spindle with a stroke of 96 in. supported its full length by an underarm ram which makes it possible to utilize the full 100 hp throughout the stroke.

A heavy manufacturing shop of today needs planer type milling machines. A 10 x 10 x 40-ft planer mill was installed in 1949, and has taken the place of five large obsolete planers. Three smaller planer type mills have eliminated six obsolete small planers. The heavy load schedule which has been against these small units since their installation necessitated the purchase of a new and larger machine. The knowledge gained in the past ten years has led to the many design changes on the present mill.

At the present time a 14 x 14 x 40-ft planer mill, Figure 8, is being installed. This mill will have four

milling heads like the original. However, instead of a single 100 hp for all of the four heads, it now has 150 hp on each head. This machine is equipped with the latest measuring devices, automatic rail leveling and a chip conveyor. The 250-ton load limit on each table will permit machining of larger forgings. The approximate cost of the foundation, in which 105 cu yd of concrete was poured, was $95,000.

Our 16 vertical boring and turning mills range in table size from 36-in. to 25-ft diam. Figure 9 shows the mill and a partly machined gear band used for reduction gearing in ship propulsion, which is representative of the type work suitable for this machine. This unit can handle 20-ft diam material up to 11 ft-6-in. high. The features incorporated in the machine's design make it one of the most powerful and versatile of its size in use today. It is no longer necessary to change feeds and speeds by hand from boxes and levers located on the housings or crossrails. The machine is controlled from a pendant which is convenient to the operator. All feeds are electronically controlled giving infinite variations through the entire range. This mill at 125 hp has twice the hp and three times the table speed of a machine which was designed ten years ago. In order to compensate for changes in diameters, machinability and other variables, the feed and speed ranges can now be changed while the machine is in operation. This machine has wider bearing surfaces on crossrails, housings, rams and other contact points making it a rugged heavy duty tool.

In addition to the new vertical mills purchased, three large mills have been completely rebuilt in the past four years. Anti-friction bearings have replaced old style bronze bearings making it possible to double the original hp of these units. New gearing installed has widened both the feed and speed ranges which are now completely controlled from the pendant. All mating surfaces including the table have been reworked to insure the accuracy and rigidity necessary for present-day operations. The reconditioning of these units has made it possible to increase production 35 per cent through the use of carbide tools, and because of the convenience of operation it is no longer necessary to have a helper assigned to these machines.

At the present time a hydraulic tracing attachment is being installed on the 84-in. vertical mill and a similar attachment is to be purchased for the 16-ft mill. The increased demands for profile machining has made these additions necessary.

The continuous improvement in cutting tools, the increase in the size of forgings, the close tolerances demanded by customers and the heavy load ahead has made it necessary to accelerate the lathe improvement program.

Many old lathes have been scrapped and replaced with new machines of the latest design. In the past ten years a total of 24 new heavy duty engine lathes ranging in size from 48 in. to 72 in. have been installed. These lathes one of which is shown in Figure 10 have the high horsepower, the anti-friction bearings, the pendant control, the hardened ground bedways and the latest design features. At least seven new turret lathes and 15 smaller lathes have been installed to replace obsolete equipment. In spite of the installation of these many new lathes it has been impossible to

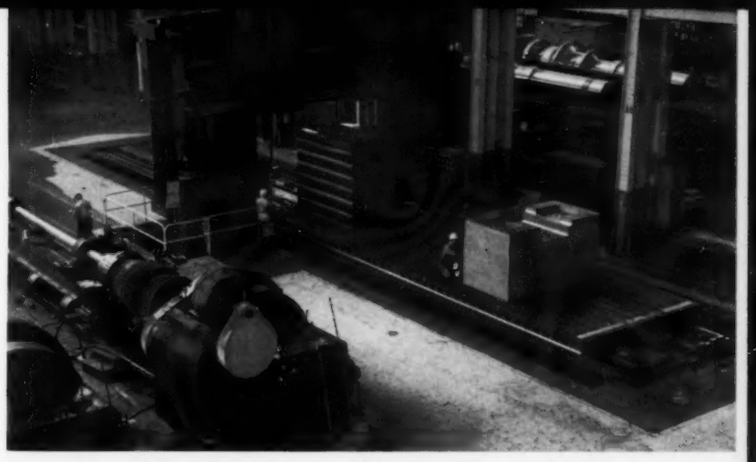


Figure 6 — Utilization of old machinery in the modernization program is illustrated by this 110-in. lathe rebuilt for carbide boring.

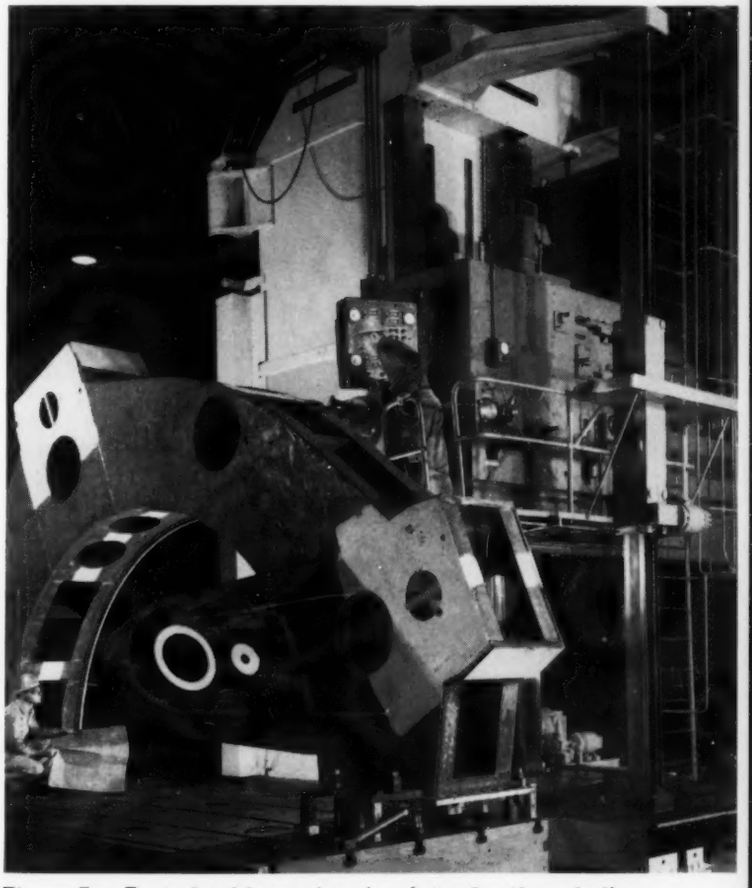
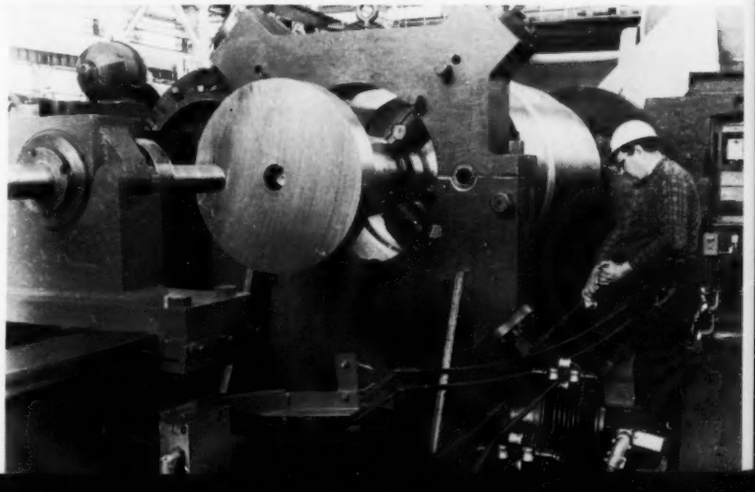


Figure 7 — Part of a ship motion simulator for the missile program at Cape Canaveral is being machined by a 10-in. spindle-size horizontal boring mill.

Figure 8 — The installation of large planer type milling machines, such as this 14 x 14 x 40-ft mill, is in line with the necessity of handling larger forgings.



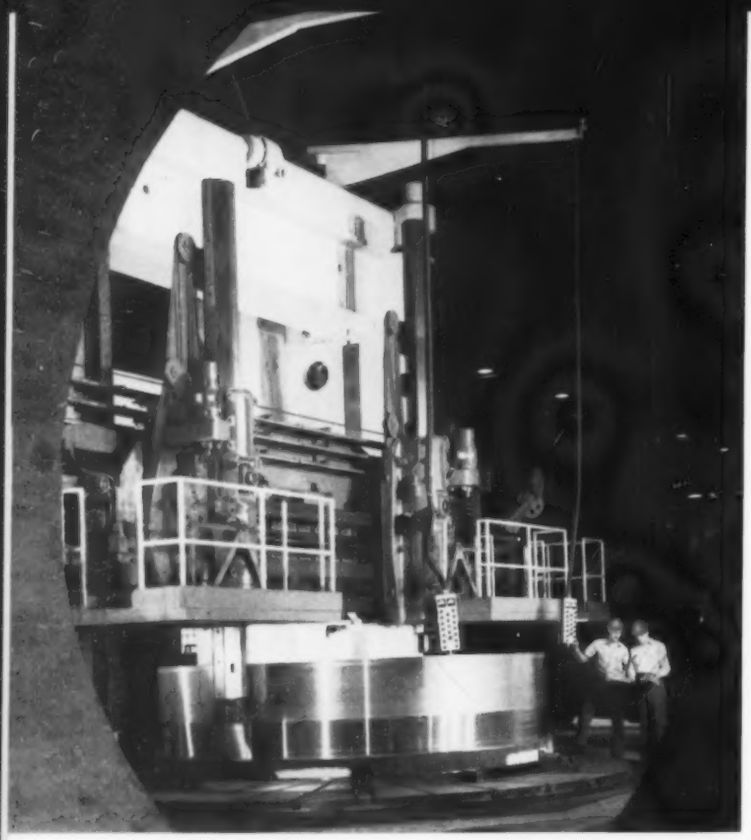


Figure 9 — A vertical boring and turning mill with a 20-ft table was installed in late 1957.

meet customer demands for rotor and generator forgings. The major factor is that the average size of the product has increased 85 per cent thus requiring more machining and larger tools, Figure 11. The sales department requested an increase in production capacity on these products from the present capacity of 40 to 55 per month, an increase of 38 per cent. After a thorough study of the needs (in conjunction with the engineering department) it was determined that in order to balance the operation it was necessary to scrap several obsolete machines in one shop and replace them with six rough turning lathes from another shop. The purchase of the following machines was also required:

Two — 84-in. lathes.
Two — 72-in. lathes.
One — 60 in. lathe.
One — 50-in. lathe.

These machines have increased annual output by 3600 tons. All of these machines have been placed in operation except the two 84-in. lathes which are now ready for delivery. These two lathes are of a new design manufactured to our specifications. The heavy duty headstock is completely enclosed having alloy steel, heat-treated matched gears to insure smooth operation. The headstock speeds will vary from a low of 1 to a high of 80 rpm. The tailstock having a 26-in. diam quill is spring-loaded to allow for linear expansion of the workpiece and is capable of carrying a load of 200 tons.

A program has been started to replace the 110-in. lathes which have been in operation for 43 years. The 138-in. swing x 45 ft center lathe presently on order is only the beginning. This new machine will have a 250-hp main drive motor allowing speeds of ½ to a

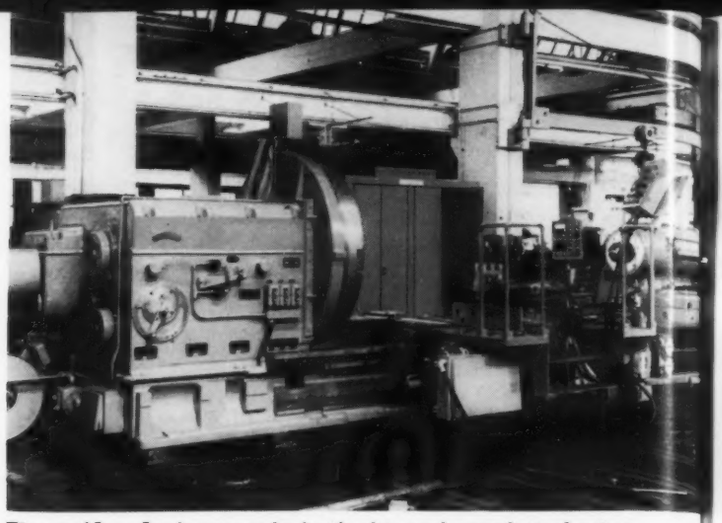


Figure 10 — An increase in both size and number of rotor and generator forgings required high-capacity engine lathes of the most modern design.

Figure 11 — A water wheel shaft is machined on a 137-in. lathe.

high of 60 rpm. This machine will have four carriages, two on the front and two on the back of the bedway. The bed is constructed so as to enable carriages on opposite sides of the machine to pass each other in addition to traveling past the steady-rest. Chutes have been cast into the bedway to properly direct the chips onto the installed chip conveyor. Chip removal will be handled with an oscillating type chip conveyor mounted in a pit under the centerline of the bed. This conveyor has a capacity of 300 cu in. of chips per min. A complete arrangement of interlocks will be installed to insure a safe operation. The new unit will be able to produce any thread or taper desired, and it will be possible to control all of the motions from a single pendant station. The tailstock has the relative dimensions to the headstock of the present 50-in. lathe.

Early in 1957 the honing machine shown in Figure 12 was installed. It is capable of honing bores ranging

in diameters from 1½ to 14½ in. The 60-in. stroke with its vertical reciprocation, head rotation and a stone pressure which is hydraulically controlled has improved bore finish tremendously. Some products are finished with keyways in a hardened bore. The spiral stones span the keyways allowing grinding within 0.0005-in. taper, concentricity and size in spite of the surface interruption.

Many times it becomes necessary to utilize the facilities on hand to produce a product. This became necessary for us during the Air Force press program. The columns for this press were 109-ft long and weighed 100 tons. These were known as the world's longest forgings. No machine was available anywhere in the world to mill a forging of this size.

However, operating personnel solved this problem after much thought. The top bar housings of a large boring lathe were removed and a 5-in. horizontal boring mill was mounted in their place. The feed was obtained from the long feed screw on the boring lathe which had 115 ft of travel. The column was mounted on concrete piers which had been located along side the bed of the boring lathe. This method of machining, Figure 4, has been labeled "pick-a-back machining." The final boring of the holes was accomplished through the use of this two machine setup.

At the present time we do not have any numerical controlled machinery. However, a first unit was included in the 1960 program. After considerable study and investigation by the committee on numerical control, it has been decided to purchase one unit for trial. A 4-ft x 13-in. numerically controlled positioning table will be ordered. The positioning table will be used to replace the manual setup now used in the drilling of various shear knives. A numerically controlled table will eliminate the need for expensive jigs and fixtures as well as eliminating the possibility of human errors since no layout will be necessary. The results obtained on this machine may lead the way for more numerical controlled facilities.

Figure 12 — The decrease in allowable taper prompted the purchase of this vertical honing machine for grinding low tolerance holes.

Now that these many fine tools have been installed, a concentrated effort must be made to insure the proper maintenance of this equipment. The electrical department must be trained to handle the many miles of wire and delicate controls, the mechanical department must study the new designs to enable them to put their finger on the trouble without excessive delay and the lubricating men must familiarize themselves with the proper lubricants necessary for these new units.

Most important of all is tool preparation and follow-up. New tooling and applications are constantly being studied, applied and followed by specialists, many carefully trained as tool engineers. These men are available on all three shifts and see that the proper tooling is applied and that the established feeds and speeds are always maintained so as to obtain maximum performance from these facilities. The end result of the program will be a safe operation, a better product and a fair return on investment.

Discussion

PRESENTED BY

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H. W. Dorset: I assume that these large machine tools that you purchased and are using today undoubtedly required some strengthening of your building. Did you do anything to strengthen building columns and your runways and what did you have to do with your overhead traveling cranes considering the 85 per cent increase in the size of the material that you are handling?

F. J. Wolfe: Back in 1890 a lot of the material was handled by horses. It was quite a laborious job to put something into a machine. The first cranes were light-duty. We are continually strengthening our building columns and our footings, and putting in extra braces. We have come to the point in a particular shop, where we shall have to move one of these days, simply because our crane capacity is not sufficient. We are trying to lift 150 tons with 100-ton cranes.

The No. 8 shop has large cranes, up to 150-ton capacity, and grouped together we can handle our 134-in. ingot. It was not only the crane. We had to have a special chain to handle that 200-ton anvil forging, and when you start to build such big chains, you are spending money. Even though we built an extra heavy-duty chain we broke it.

However, the biggest problem is getting the material out of the shop and over the road to its end destination. The railroads have a difficult job, with narrow passages, low bridges and cinder beds. The traffic department has to do a lot of exploring before they can direct the job to the site. ▲

The Transient Temperature Distribution Within Slabs Heated in Continuous Furnaces

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. . . . proper rearrangement of the skids in a slab-heating furnace can change the temperature profile along the length of the stab—which can effectively reduce off-gage conditions in the finished strip . . . .

THE presence of water-cooled skids that support slabs during the heating process in continuous reheat furnaces is the principal source of longitudinal temperature variation in hot-rolled steel strip and subsequently the periodic gage variation in the finished strip. This defect, if severe, can result in rejection of the finished product for critical applications.

Attempts to minimize this temperature variation, by means other than complete soaking, inherently involve changes in the furnace. To investigate the effectiveness of such changes in improving the uniformity of slab heating, it becomes essential to establish the manner in which the transient temperature distribution varies within the slabs and the dependence of this distribution upon the method of support.

Using a mathematical model for the heating process, the method of finite differences for solution of the differential equation of heat flow in two dimensions with boundary conditions dependent on time is applied. The computed temperature histories for a conventional 3-zone furnace are given in graphical form. In this investigation, the heat flow in the steel in the direction of the furnace length is neglected.

Analysis of the results demonstrates the feasibility of improving the degree of temperature uniformity by means other than complete soaking. Two methods are investigated; one involves raising the skid-coolant temperature, and the second involves changes in the geometrical configuration of the skids. Improvement as high as 80 per cent in the degree of temperature uniformity is possible by the use of an alternate skid configuration. The results of this study point the way not only to improvement in temperature uniformity, but also to possible increase in furnace productivity.

STATEMENT OF THE PROBLEM

In hot strip mills, slabs are heated to rolling temperature in continuous reheat furnaces where heat is supplied to the steel through its upper and lower surfaces. The slabs are pushed intermittently, one behind the other, into the furnace to form a horizontal steel layer moving in a direction opposite to that of the flow of the heating gases.

In the heating zone of the furnace, the slabs are supported on water-cooled skids. The areas of contact of the slabs with the skids are not only shielded from direct heating, but also cooled by the skids that provide a thermal path through which heat is conducted from the slabs to the cooling water. It is the practice to maintain this water at a mean temperature of 100 F. Figure 1 shows a section of this furnace construction and detail of the skid construction.

The regions of skid contact are not raised to the

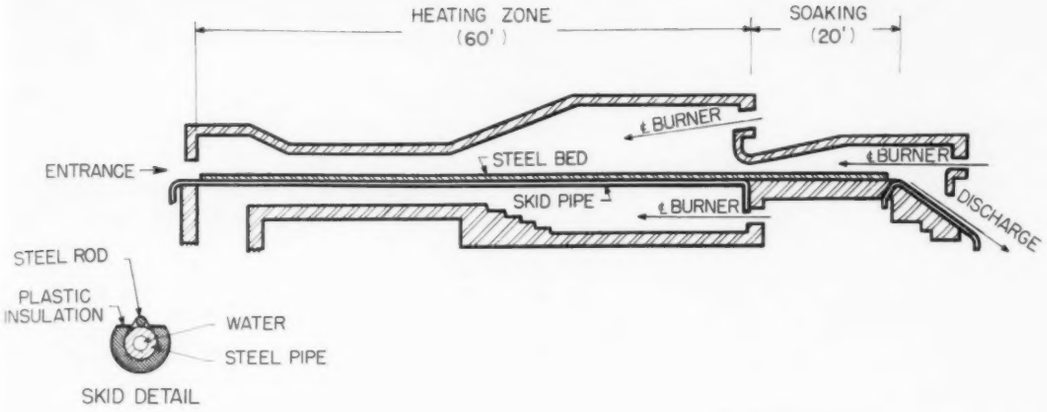


Figure 1 — A conventional slab - heating furnace was used as prototype in determining data required.

same level of temperature as other slab parts, and an appreciable temperature variation exists in the slabs as they enter the soaking zone. This is illustrated qualitatively in Figure 2. Because of the equalizing effect of the soaking zone, this longitudinal temperature variation is reduced in magnitude; nevertheless, it persists to a significant degree in the slabs as they leave the furnace. Phillips[1]* has pointed out that this temperature variation is the principal cause of periodic thickness variation along the finished strip. During rolling, this temperature variation exhibits itself as a fluctuation in the magnitude of the resistance to deformation of the material being rolled. Thus, the rolls spring further apart at the colder spots, causing the strip to be thicker at these spots than at other parts. This variation persists in the finished strip and is a defect that, if severe, can result in rejection of the finished product for critical applications. Therefore, it is highly desirable to minimize the thickness variation in the finished product.

There are two basic ways to achieve this:

1. By elimination of the effect, which involves the use of automatic gage regulators that change roll pressure by screw control or regulate interstand tension or a combination of both.

2. By elimination of the source, which involves minimizing the magnitude of the temperature variation prior to rolling.

The first approach has received considerable attention as pointed out in recent publications by Maxwell[2] and Phillips.[3] However, the second approach was pursued because it is desirable from a fundamental viewpoint. In addition, this approach would considerably simplify and reduce the cost of automatic gage control systems, for such systems would have to compensate only for the gradual variation of temperature along the strip due to loss of heat while rolling.

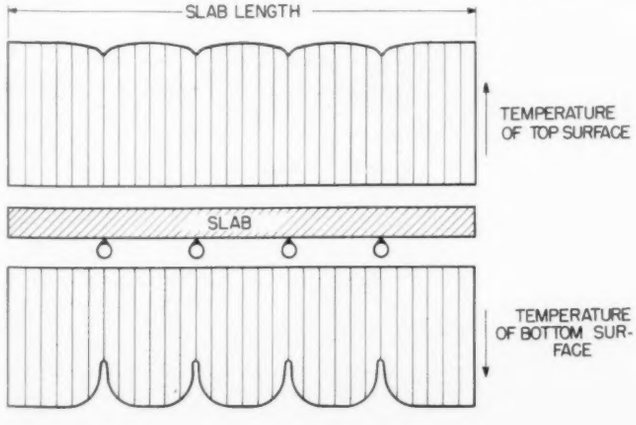
Complete soaking presents the rather obvious but economically unacceptable solution to the problem; because, if it were achieved by increasing the soaking time, it would reduce furnace productivity; whereas, if it were achieved by lengthening the soaking zone, it would considerably increase furnace installation and operation costs. Since the longitudinal temperature variation is caused by the skids, means to minimize this variation would inherently entail changes in the method of support.

To investigate the effectiveness of modifications in the method of support or any means other than complete soaking in reducing skid marks, and to compare their relative merits, it becomes essential to establish the manner in which the method of support influences the heating uniformity of the slabs.

The purpose of this paper is to present theoretical results regarding the effectiveness of various proposals in minimizing the skid effect without resort to experiment under actual operating conditions. These theoretical investigations were carried out by developing a mathematical model for the furnace and using heat transfer theory analysis with the help of an electronic digital computer. The results obtained in this study have justified the approach to the problem.

* Numbers refer to references in Bibliography.

Figure 2 — Contact with the furnace skids reduces the slab temperature at those points and causes rolling problems.



METHOD OF INVESTIGATION

To determine the temperature distribution in the slabs under time-dependent boundary conditions, in two dimensions with singularities at the areas of skid contact, the Fourier heat conduction differential equation has to be solved to satisfy these conditions. A careful search in the unclassified literature did not reveal exact solutions for the problem. Attempts to extend solutions obtained during the course of this work at United States Steel Corp.'s Applied Research Laboratory to include the effect of the skids clearly indicated that such an endeavor would indeed be of extreme mathematical complexity. Therefore, the method of finite differences was used.

To provide boundary conditions similar to those

encountered in actual furnaces, an idealized mathematical model that represents the heating process in the furnace was developed. This model is composed of three basic elements:

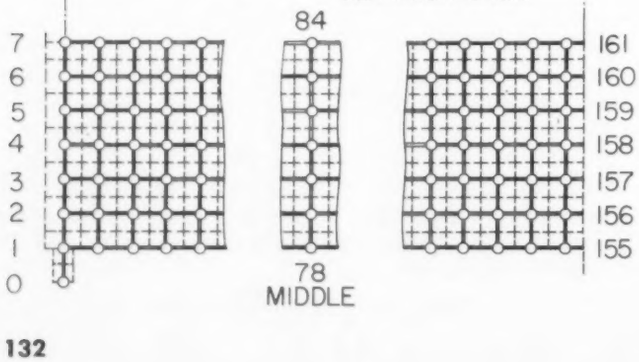
1. A top and a bottom heating zone, each of which is provided with a constant temperature radiant heating source. This serves to establish the heating rate for the slabs in the heating zone.
2. A soaking zone where the slabs are adiabatically held to equalize the temperature inside them.
3. A grid of nodal points and thermal conductances to represent the slab and skids. This is shown in Figure 3.

ASSUMPTIONS

In developing the mathematical model the following assumptions which lead to simplifying the physical system were made:

1. The slab material is isotropic.
2. The slab can be divided into geometrical subdivisions, each of which is replaced by a nodal point that has the same heat capacity as the subdivision it represents, lumped and concentrated at that point. The nodal points are connected to each other by thermal conductances equivalent to the conductance of the solid between them. This composes a grid, which is shown in Figure 3.
3. Only the local temperature of a nodal point and the temperatures of adjacent nodal points need be considered in calculating the change in the local temperature during the chosen time interval.
4. The selected time interval is small enough so that the initial rates of heat flow can be used over this interval.
5. The change in heat storage in an element may be calculated from the change of temperature of the reference nodal point located in that element.
6. Average values of the thermal conductivity, the specific heat and the density can be used.
7. Heat is transferred to the top and bottom surfaces of the steel by radiation from sources at a constant temperature.
8. The change in the temperature of the skid-cooling medium in the furnace is small; therefore, an average constant value can be used.
9. In the soaking zone, no heat is exchanged between the steel and the surroundings.
10. The thermal contact resistance between the steel and the skids is neglected, since the bearing pressure between the steel and the skid is of sufficient magnitude.
11. The interior surface of the skid pipe is at the average temperature of the cooling water.

Figure 3 — The method of finite differences is applied to this problem using a network of nodal points.



CORRECTION OF THE SOURCE OF TEMPERATURE VARIATION

The mathematical model for the furnace was used to study two different methods of minimizing the skid-produced temperature variation:

1. A method that involves keeping the conventional geometric arrangement of the skids, but raising the mean temperature of the cooling medium.
2. A method that involves displacing each skid parallel to itself one or more times at various points, thereby exposing the skid contact areas to cooling and heating alternately.

SOURCES OF DATA AND PROPERTIES OF STEEL

The subject of these studies was a pusher-type continuous slab-heating furnace. This is a 3-zone furnace that has top-and-bottom-fired heating zones 60 ft in length, and a dry skid soaking zone 20 ft long. This furnace is equipped with four straight skids that extend the entire length of the heating zone.

As stated in the assumptions, the properties of steel slabs were assumed to be constant; the temperature of the heating sources was also assumed to be constant. The following values of various parameters were used:

Thermal conductivity of steel	21 Btu per hr, ft, F[4]
Specific heat	0.168 Btu per lb, F[4]
Density of steel	480 lb per cu ft[5]
Slab thickness	Six in.
Temperature of heat source	2450 F[6]
Initial slab temperature	70 F
Combined emissivity factor	0.45[7]
Time in furnace	two hr
Distance between skid centerlines	44 in.

It is therefore pertinent to mention here that the data presented refer only to the present example. Optimum conditions can be computed for any other type of furnace, slab thickness, or heating conditions, using the same procedure of calculation with the required changes in boundary conditions. Results for other furnaces and conditions may be quite different from the data presented, depending upon the extent of departure from the conditions for which the present computations were made.

CALCULATIONS

The iterative finite difference method used is patterned after the method described first by Emmons[8] and later by Dusinberre.[4] Because the heat conduction field is symmetric, it was possible to conduct the calculations only for half of the slab part between two skids. This field is divided into 161 nodal points, each of which represents one sq in. of the steel cross section. These nodal points are connected by fictitious heat-conducting rods as illustrated in Figure 3. The plane of stations 78 and 84 is the center of this field. Because

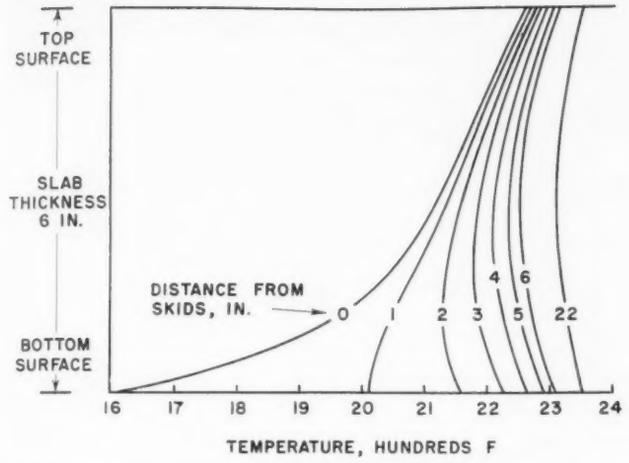


Figure 4 — Temperature distribution curves before soaking indicate that isothermal conditions are approached a small distance from the skid contact point.

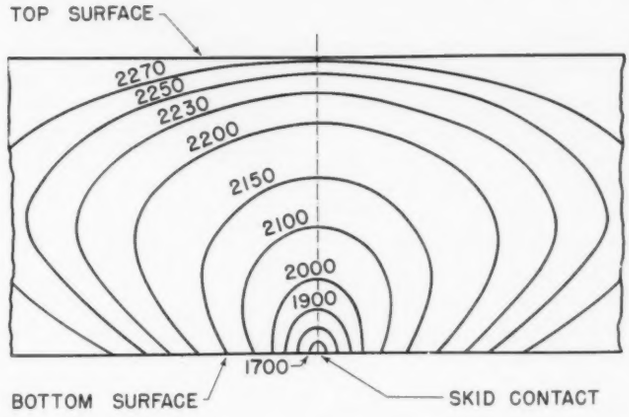


Figure 5 — Concentration of the cooling effect of the skid is indicated by the theoretical isotherms drawn for a mean cooling water temperature of 100 F.

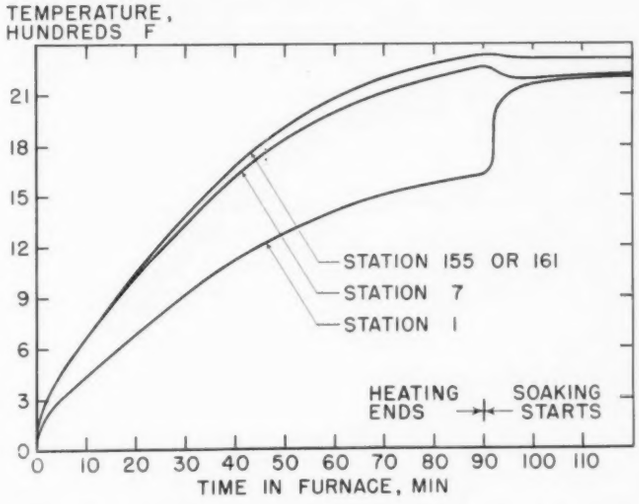


Figure 6 — During its push through the furnace, the slab requires a large temperature difference between various points on its top and bottom surfaces.

the number and extent of computations would be prohibitive otherwise, the heat balance equations were programmed for solution on a digital computer. For the program, it was necessary to use a second grid of 161 extra points. At any time during computation, one of these grids was worked from and the computed information was stored in the other. This order was reversed at the end of each iteration. The calculations for heat transfer to the slab surfaces, to the cooling water, and the heat diffusion into the slab were repeated every 20 sec. Each case considered required 364 iterations during which the corresponding set of equations was applied to each one of the 161 nodal points.

RESULTS AND DISCUSSION

The effect of the skid presence on the temperature field has been investigated for the conventional case in which the mean temperature of the skid-cooling water is 100 F. Figure 4 shows the temperature distribution at the end of the heating period in slab planes at various distances from the skid. In Figure 5, the theoretical isotherms are drawn for the slab after the heating period. Both these figures clearly indicate the concentration of the cooling effect in the immediate vicinity of skid contact. The skids have a relatively small effect per unit distance on the temperature profiles for distances exceeding six in. from the skid centerline. Beyond this distance, the temperature profile is parabolic and agrees well with exact analytical solutions for the case of no skids.

Figure 6 is a plot for the temperature history of the top and bottom surfaces of the steel at the plane of the skid and at a plane midway between two skids. It shows how these temperatures vary as a function of the position of a slab in the furnace. The plot also indicates that only a small temperature variation exists in the top surface of the slab during heating as compared to the difference between points on the bottom surface. It may also be observed that the rate of temperature rise of the top steel surface is practically linear in the early stage of heating and decreases towards the end of the heating period. The rate of temperature rise of the steel in contact with the skid follows a similar course. These temperature plots show that, for the case under consideration, a maximum temperature difference of 723 F exists between the hottest and coldest points in the slabs at the end of the heating period. This difference is reduced to only 94.2 F at the end of the soaking period.

Effects of raising skid-coolant temperature—To investigate the influence of the coolant temperature on the heating uniformity, additional computations were carried out for skid-coolant temperatures of 300, 500, 700 and 900 F. It became clear during analysis that the temperature field for a coolant temperature of 100 F is qualitatively representative of the temperature field in the other cases. Therefore, temperature field

TABLE I
Summary of Skid-Coolant Temperature Effect on the Maximum Temperature Difference

Temperature of skid coolant, F	Maximum temperature difference, F		Per cent reduction in maximum temperature difference
	End of heating	End of soaking	
100	723	94.2	0
300	655.6	84.6	10
500	589.5	75	20.2
700	524	65.8	30
900	459.3	56.5	40

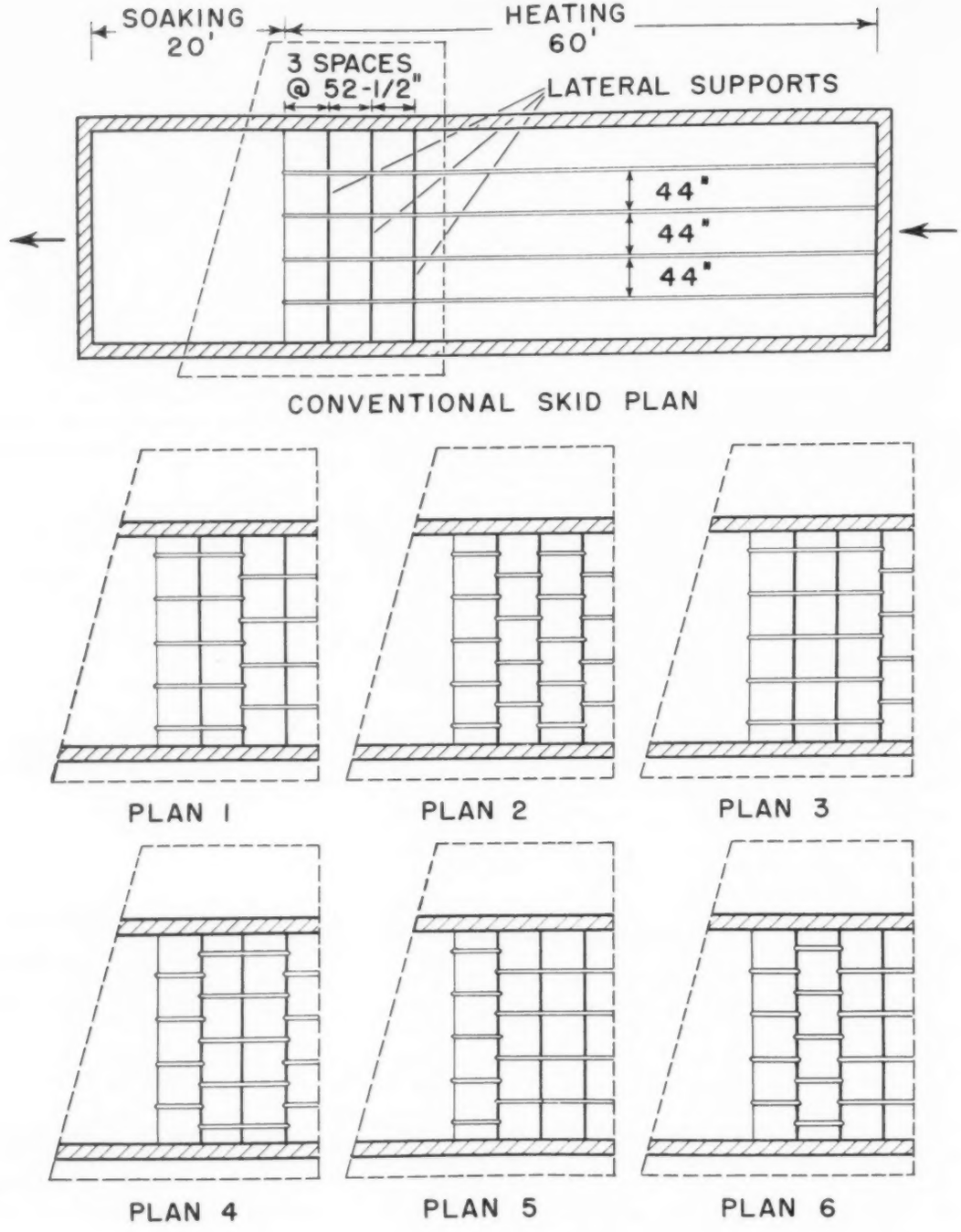


Figure 7 — Six alternate skid positions were used during the experimental work.

plots were not made for these cases.

Table I presents the values of maximum temperature differences in the slabs at the end of heating as well as at the end of soaking. The table shows that an improvement of up to 40 per cent in the temperature uniformity may be obtained by the use of a skid-coolant temperature of 900 F and that the improvement in the degree of uniformity is linearly proportional to the skid-coolant temperature.

Effects of changing skid geometry—In the reheat furnace investigated, there are three lateral water-cooled supports, which are located near the end of the heating zone and preceding the soaking zone. These lateral pipes support the skids in this region and provide the most convenient positions to displace the skid centerlines. Six alternative arrangements of staggered skids, where the skid centerlines were displaced parallel to themselves at the lateral supports, were investigated. These alternative skid configurations are shown in Figure 7. The temperature course at points of maximum and minimum temperatures which are on the surface of the slab is plotted as a function of position in the furnace in Figures 8 through 14. The temperature variation with the slab position in the furnace is plotted in each of these figures from the location of the first of the lateral supports.

The results of computation indicate that the skid arrangement shown in the first alternative plan results in a maximum temperature difference of 18.1 F. Compared with the maximum difference of 94.2 F obtainable with the use of the conventional skid plan shown, this alternative plan represents an improve-

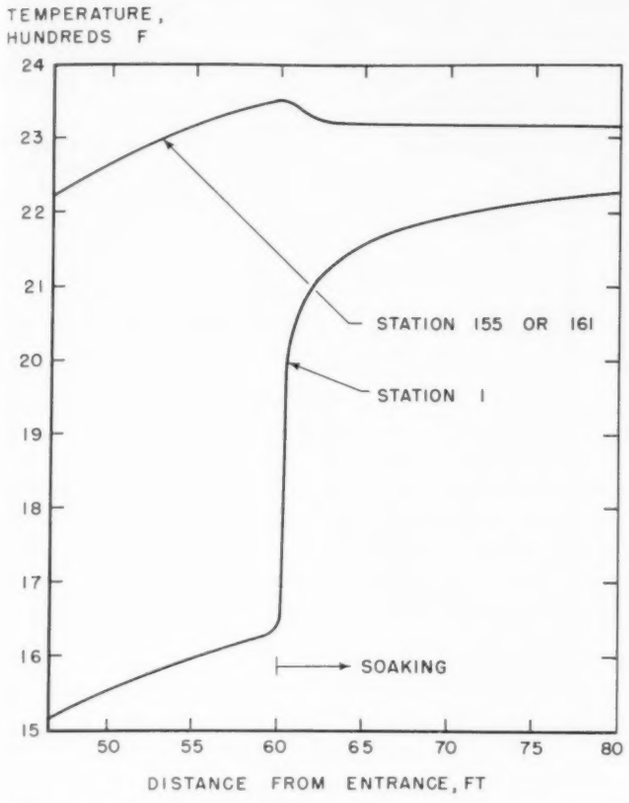
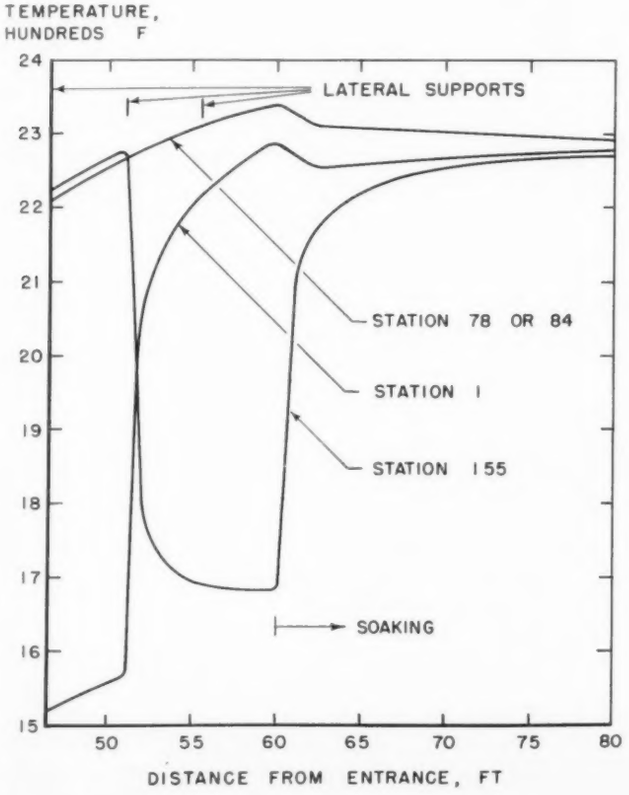


Figure 8 — Curves of slab-surface temperature at various points vs position in the furnace for a conventional skid arrangement show a wide variance in temperature prior to the soak cycle.

ment of 80.8 per cent in the degree of temperature uniformity.

Table II summarizes the results of computations to evaluate furnace performance with the alternative skid arrangements shown. The second column in this table lists values of the maximum temperature difference existing in the slabs at exit from the furnace when the various skid plans are used. In the third column, these differences are expressed as percentages of the maximum temperature difference obtainable from a furnace with the conventional skid arrangement. The table shows that the furnace performance may be improved to various degrees by using any of the skid arrangements investigated. The improvement ranges from the significant value of 80.8 per cent with the best plan down to 40.3 per cent.

Figure 9 — Temperature variation vs distance for alternate skid plan No. 1.



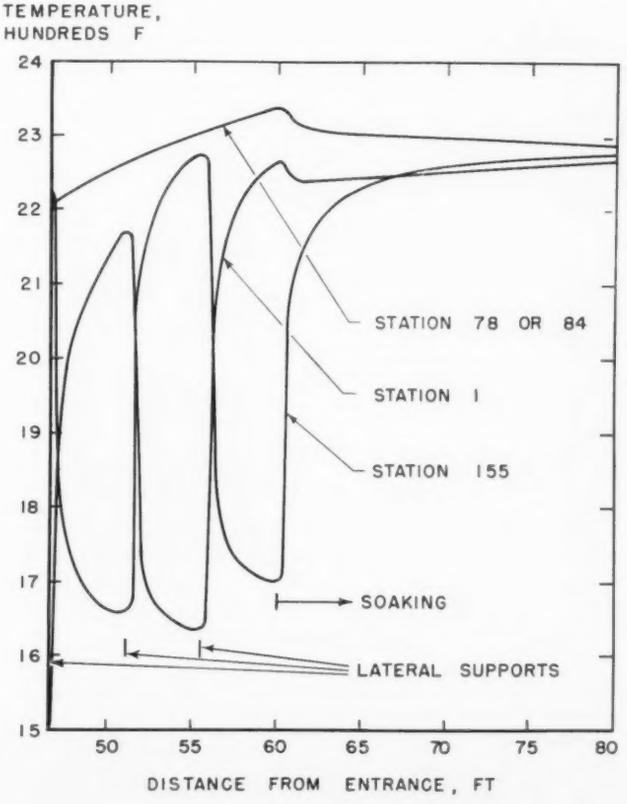
SUMMARY

Skid marks are the principal source of periodic gage variation. Methods to minimize these marks, by means other than complete soaking, inherently involve modifications in the skids. To evaluate such modifications, a mathematical model for the heating process in conventional slab-heating furnaces is developed with the help of simplifying assumptions and the use of the method of finite differences for solution of the differential heat transfer equation.

The method of investigation developed in the course of this work is being applied to a study of the performance of existing United States Steel Corp. furnaces under conventional conditions and with modifications in the skids.

The effects of two types of proposals regarding the skids upon the uniformity of heating of slabs at their exit from the furnace are investigated. These results are compared with the uniformity of temperature obtainable under conventional conditions.

Figure 10 — Temperature variation vs distance for alternate skid plan No. 2.



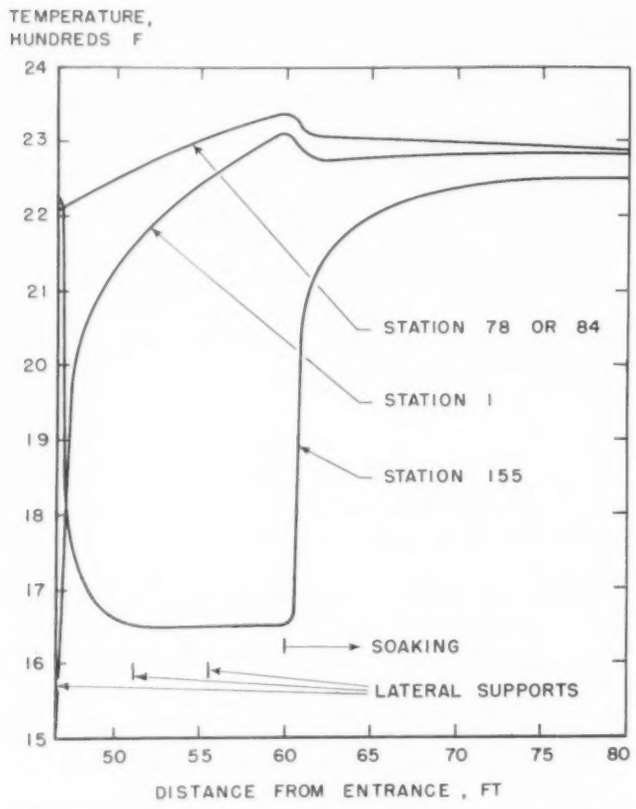


Figure 11 — Temperature variation vs distance for alternate skid plan No. 3.

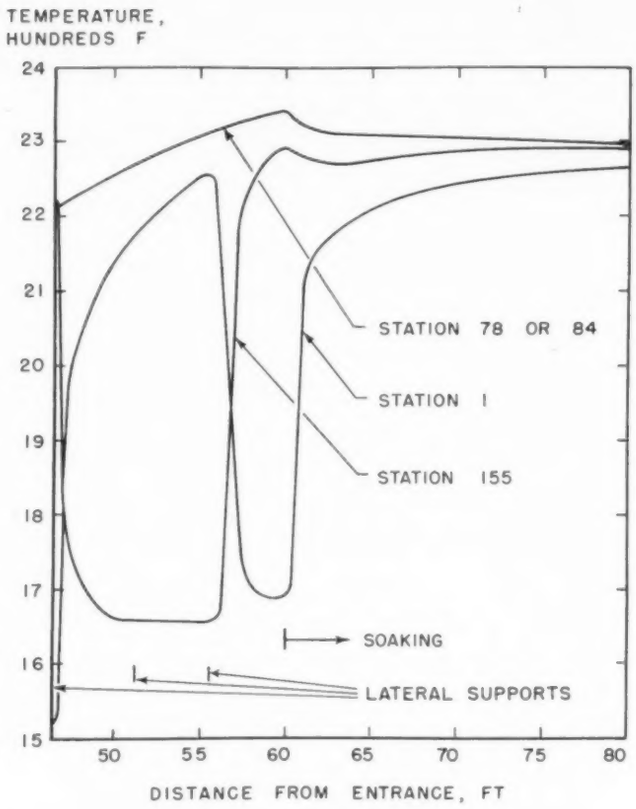


Figure 12 — Temperature variation vs distance for alternate skid plan No. 4.

Computations for a method involving raising skid-coolant temperatures reveal that a rise of coolant mean temperature from 100 to 900 F results in a linear improvement in the temperature uniformity reaching 40 per cent at the upper temperature limit.

Investigation of a method that involves six alternative skid configurations without changing the presently used cooling-water temperature reveals that significant

Figure 13 — Temperature variation vs distance for alternate skid plan No. 5.

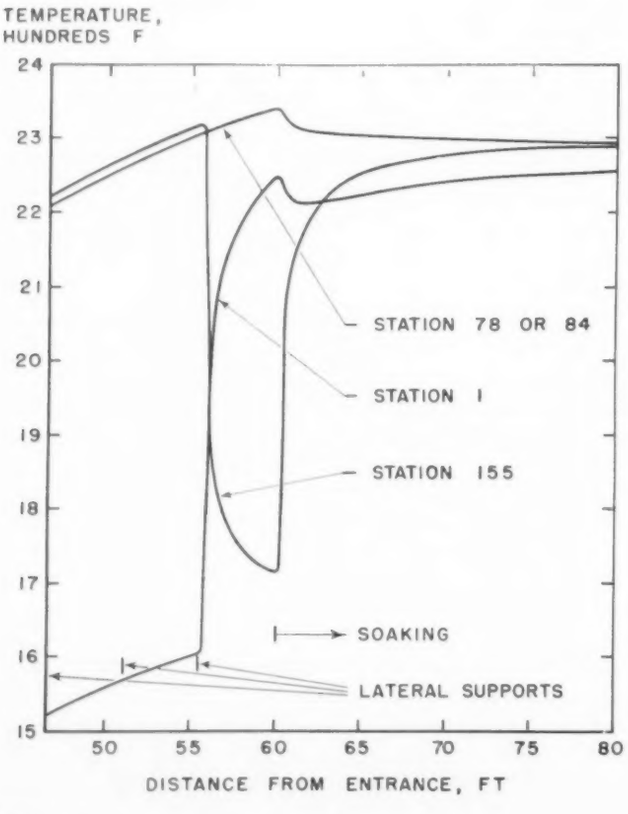


Figure 14 — Temperature variation vs distance for alternate skid plan No. 6.

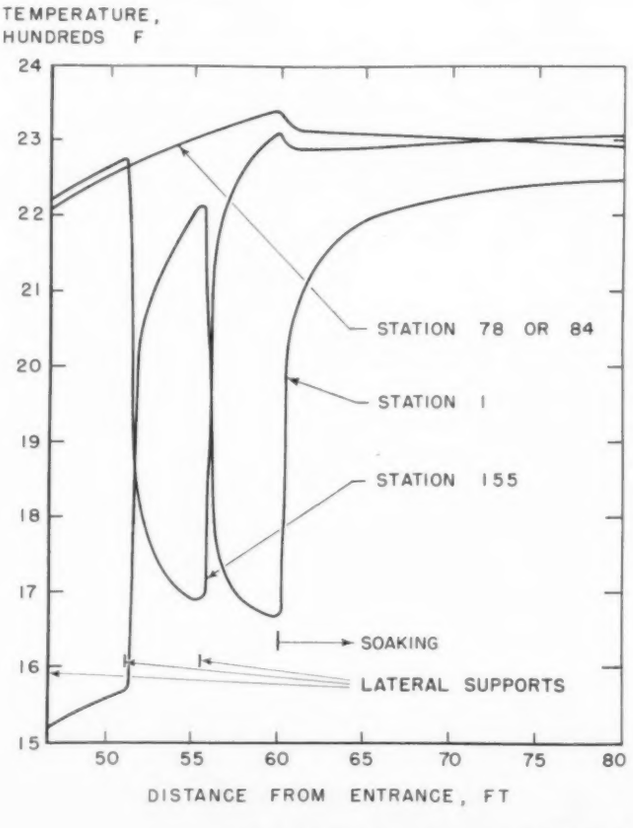


TABLE II
Summary of Maximum Temperature Differences at Exit from Furnace

Skid configuration	Maximum temperature difference, F	Per cent reduction in maximum temperature difference
Conventional	94.2	0
1	18.1	80.8
2	22.7	75.9
3	34.5	63.4
4	34.8	63
5	41.2	56.3
6	56.2	40.3

improvement in furnace performance with regard to heating uniformity is possible with this method. This improvement is over 80 per cent for one of the skid configurations investigated. In this configuration, the skids are displaced parallel to themselves close to the end of the heating zone. The new position is midway between the conventional positions of the skids. Conversion from presently used skids to those proposed may be carried out at nominal cost.

To summarize briefly, the principal conclusions are as follows:

1. A method has been developed which provides a means for evaluation of possible changes in furnace operations or construction to minimize skid marks.
2. Theoretical analysis demonstrates the advantage of displacing skid centerlines.
3. There is an optimum shape for the skid stagger for any given set of operating conditions.
4. The results of the work reported will not only make possible a significant improvement in the heating uniformity of slabs, but also suggest possibilities of increase in furnace productivity.

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APPENDIX

Heat Transfer Equations

The physical field chosen was half that between skids because of conditions of symmetry. Its interior was divided into 1-in. squares and the surface layer was divided into 1 x ½-in. rectangles. The subdivided field was then replaced by 161 nodal points, as shown in Figure 3. The nodal points have the same heat capacities as the elements they replace and are connected to surrounding points by means of equivalent thermal conductances. Equations are derived for a mathematical model of the heating process in the furnace in order to carry out the finite difference procedure of computation. These equations can be classified by category as follows:

TABLE III
Nomenclature

- T_i = The temperature of the interior nodal point i at the start of an iteration
- T'_i = The temperature of the interior nodal point i at the end of an iteration
- T_i' = The temperature of a nodal point which is the mirror image of the point i, at the start of an iteration
- F_{lm} = The influence coefficient of a nodal point l on the point m
- Q = A temperature rise term representing heat exchange
- k = The mean thermal conductivity of steel Btu per sq ft, unit temperature gradient, degree Fahrenheit
- $\Delta\theta$ = The period of iteration or the time interval
- Δx = The length of the side of the geometrical square subdivision
- β = The portion of the exposed part of the element in contact with the skid, expressed as a fraction of the total length of the side of this element
- C = The average specific heat of steel over the temperature range considered
- ρ = The steel density
- h = The thickness of the steel separating the slab from the skid coolant
- $\epsilon_1\epsilon_2$ = The equivalent emissivity of flame and roof
- t_r = The temperature of the radiant hypothetical heat source
- C_j = The heat capacity of a nodal point j
- ΣK_j = The sum of conductances between a nodal point j and its immediate neighboring nodal points
- n = The number of nodal points on the regular matrix column which excludes the nodal point o
- a = A subscript referring to the point of contact
- 0 = A subscript referring to the skid interior surface
- s = A subscript referring to the surface point

1. Equations applicable to the point of contact between the skid and the slab. Conditions referring to this point are designated by the subscript a, see Table III. These may be written as:

$$T'_a = F_{(a+n)a}\,T_{(a+n)} + F_{(a+n)a}{}'\,T_{(a+n)}{}' + F_{(a+1)a}T_{(a+1)} + F_{0a}T_0 + F_{aa}T_a + Q_a \quad (1)$$

$$F_{(a+n)a} = \frac{0.04\,k(\Delta\theta)}{[(\Delta x) + (1-\beta)h]\,(\Delta x)C\rho} = F_{(a+n)}{}'_a \quad (2)$$

$$F_{(a+1)a} = \frac{0.08\,k(\Delta\theta)}{[(\Delta x) + (1-\beta)h]\,(\Delta x)C\rho} \quad (3)$$

$$F_{0a} = \frac{0.08\,k\,(1-\beta)\,(\Delta\theta)}{h[(\Delta x) + (1-\beta)h]\,C\rho} \quad (4)$$

$$F_{aa} = 1 - [2F_{(a+n)a} + F_{(a+1)a} + F_{0a}] \quad (5)$$

$$Q_a = \frac{115.32 \times 10^{-5}\beta(\Delta\theta)\,(\epsilon_1\epsilon_2)}{[(\Delta x) + (1-\beta)h]C\rho} \times \left[\left(\frac{t_r + 460}{100}\right)^4 - \left(\frac{T_a + 460}{100}\right)\right] \quad (6)$$

2. Surface points of the matrix other than the point of contact between the skid and slab. For these points, the following equations have been derived:

$$T'_s = F_{is}\,T_i + F_{(s-n)s}T_{(s-n)} + F_{(s+n)s}T_{(s+n)} + F_{ss}T_s + Q_s \quad (7)$$

$$F_{is} = \frac{0.08\,k\,(\Delta\theta)}{(\Delta x)^2 Cp} \quad (8)$$

$$F_{(s-n)s} = \frac{0.04\,k(\Delta\theta)}{(\Delta x)^2\,C\rho} = F_{(s+n)s} \quad (9)$$

$$F_{ss} = 1 - [F_{is} + F_{(s-n)s} + F_{(s+n)s}] \quad (10)$$

$$Q_s = \frac{115.32 \times 10^{-5} (\Delta\theta) (\epsilon_1\epsilon_2)}{(\Delta x)\ C\rho} \times \left[\left(\frac{t_r + 460}{100}\right)^4 - \left(\frac{T_s + 460}{100}\right)^4\right] \quad (11)$$

3. Interior points of the matrix.

$$T'_i = F_{(i-1)i}\, T_{(i-1)} + F_{(i-1)i}\, T_{(i+1)} + F_{(i+n)i}\, T_{(i+n)} + F_{(i-n)i}\, T_{(i-n)} + Q_i \quad (12)$$

For the case under consideration, where there is a square matrix and no sources or sinks of heat, the following mathematical statements apply:

$$F_{(i-1)i} = F_{(i+1)i} = F_{(i+n)i} = F_{(i-n)i} = \frac{0.04\ k\ (\Delta\theta)}{(\Delta x)^2\ C\rho} \quad (13)$$

$$F_{ii} = 1 - 4\, F_{(i-1)i} \quad (14)$$

$$Q_i = 0 \quad (15)$$

Criterion—In order not to violate the heat balance equations, or, in other words, the second law of thermodynamics, the following condition must be satisfied for all points of the system:

$$\Delta\theta \leq \Delta\theta_j = \frac{C_j}{\Sigma K_j} \quad (16)$$

where j may take the value of a, i, or s referring to the skid contact point, an internal point or a surface point, whichever point renders the minimum value of the fraction: $C_j/\Sigma K_j$

Soaking condition—For soaking, the following conditions are used:

$$F_{0n} = Q_a = Q_s = Q_i = 0 \quad (17)$$

Discussion

PRESENTED BY

F. S. BLOOM, President, Bloom Engineering Co., Pittsburgh, Pa.

DR. A. H. EL-WAZIRI, Senior Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

R. V. CORDINGLY, Assistant General Superintendent, Indiana Harbor Works, The Youngstown Sheet and Tube Co., East Chicago, Ind.

H. H. DINEEN, Chief Engineer, Rust Furnace Co., Pittsburgh, Pa.

F. S. Bloom: Dr. El-Waziri's mathematical analysis seems to check very well with the tests which Ward Percy of United States Steel Corp. has presented to the AISE in previous discussion. From his work, we can expect that the temperature difference caused by the skid pipe may be even greater in cases where the tonnage output of the furnace is more than that considered in this paper.

The author has taken a furnace which is 80 ft long consisting of a 60-ft top and bottom fired main heating zone and a 20-ft soaking zone. He has also taken a time in the furnace of two hr for 6-in. thick steel slabs, which means that he is operating at a rate of 120 lb per sq ft per hr, while most furnaces on today's strip mills are operated at a rate of 165 lb per sq ft per hr. The skid mark is not an unknown factor, and all will agree that the skid mark trouble is more pronounced as the tonnage output from the furnace is increased. Would you, from your mathematical analysis, expect this condition to be true?

The author comes up with the recommendation that if the skid pipes are offset for a distance of 109 in., the problem can be solved. This solution looks reasonable except that it presents some mechanical difficulties, particularly with 2-row operation and the mechanical strain set up on the crossovers.

Of course, it must be realized that in case of a mill delay, the slab which is offset ends up by having a skid mark which is no better than it was before, because this analysis is based roughly upon having the slab on the offset skids a time of 13½ min so that if it is delayed on the offset skids for a period of approximately 20 min, we immediately end up with the same skid mark that you would have in a conventional furnace. However, this situation will occur only on two slabs.

Since the problem is being given considerable thought by all strip mill operators, is there any other way of finding a solution? As is suggested, the best solution to the problem is to heat the underside of the slab where it is cold. Why is it necessary to do this heating operation while the slab is on the skids, because while we are eliminating a cold spot at one point, we are likewise adding a cold spot at another point? However, the method presented by the author indicates that the cold skid mark can be eliminated if heat is applied to the bottom for a very short time; about 15 min. This immediately suggests the possible solution of installing a trough in the hearth of the soaking zone into which burners could be applied to supply the necessary heat to overcome the black skid mark on the bottom side. This is not an impossible construction, though the trough could fill up with scale and might cause a severe maintenance problem.

However, in defense of this subject, we must realize that the scale on the slab surrounding the skid mark cannot be of any magnitude, because that part of the slab has never been heated very hot. The trough need not extend the full length of the soaking hearth and pneumatic means could be provided to maintain the trough relatively free of scale. Certainly, a little ingenuity in furnace design might help solve this problem.

What else could be applied to the furnace? It is possible to conceive that with modern burners we could make an application of fuel to the roof of the furnace so as to create a narrow hot streak directly above the skid mark. The steel is on the soaking hearth at the proposed rate for approximately 30 min. If we subjected the cold skid mark streak to a temperature of 2550 F from a roof source fairly close to the steel, it is possible to superheat the top of the slab so that the combined section of top and bottom have the total heat required for the section, and we would expect a specific area to become equalized in the roughing mill.

We know one plant which claims they have improved

their skid mark difficulty by increasing the height of the wearing strip on their skid pipes. Perhaps Dr. El-Waziri will agree that this is a step in the right direction, because if they make the wearing strip 2-in. high instead of 1-in. high, they should reduce the temperature loss in direct proportion to the height of the wearing strip.

The author used a skid pipe covered with refractory material. What advantage does the refractory material have on the magnitude of the skid mark as compared to a skid pipe without refractory material covering?

There are a number of other questions which should be asked and which the computer might be able to give us an answer; namely,

1. Is the skid mark greater or less if we heat slabs thicker than six in.?
2. If we were to heat the slab hotter on the bottom than on the top, would the skid mark be less when the piece soaked out on the solid hearth?

Dr. A. H. El-Waziri: Mr. Bloom states that in the work presented, the heating time for the 6-in. slab selected for computation is two hr, and that from the rates of operation used in practice this heating time is more likely to be 1½ hr or less. "The Modern Strip Mill" published by the AISE contains curves giving the heating time recommended for good practice. These curves indicate that the recommended heating time for 6-in. slabs ranges between 2¼ and 2¾ hr for a mean slab temperature of 2100 to 2400 F.

This indicates that a heating time of two hr is within the realm of good practice for this type of furnace. The point that we would like to make clear is that the purpose of this work is to evaluate various means of removing marks as compared to conventional operation, rather than to duplicate the performance of an actual furnace.

In actual operations the skid marks become more pronounced as the tonnage output from the furnace is increased, and we believe that the mathematical model developed would exhibit the same tendency. This would be true provided that the maximum temperature in the slabs was the same at the end of the heating period, so that there would be a basis for the comparison.

The mechanical difficulties referred to by Mr. Bloom do not seem to be unsurmountable and I am sure could be solved by proper design.

The possible method of placing a heating trough in the hearth of the soaking zone in which burners could be placed to supply the heat necessary to even out the black skid marks on the bottom side was considered at the outset of this work, together with several other proposals that immediately suggested themselves. However, it was believed that this particular solution would create cumbersome maintenance and control problems. The control problem is critical because if the heat input to the steel in such an arrangement were not closely controlled, it could be either inadequate or excessive. Thus the cold spot could be underheated or overheated; the result would be either failure to eliminate the cold spot or creation of the reverse problem, that is, zones of lower resistance to deformation where the cold spots had been. The most critical part of this solution would be the control problem.

The refractory material covering the skid pipe serves two purposes:

1. It reduces the total heat loss from the furnace to the cooling water.
2. Because of the low thermal conductivity of the refractory, its surface temperature is far higher than that of a bare skid pipe. The heat loss to the skid pipe by radiation from the slab is reduced and consequently the skid marks are less severe than they would be in the case of an uncovered pipe.

If we were to maintain the same tonnage output, we would expect the skid marks to be more severe in heating slabs thicker than six in. However, this statement will have to be investigated for any individual case under consideration.

The possibility of heating slab bottoms to a higher temperature than the top surface is being investigated at present by the use of the mathematical procedure developed, and an evaluation of its effectiveness in removing skid marks is under way.

R. V. Cordingley: We were especially interested in the alternative skid arrangements at the exit end of the heating zone. A staggered skid plan would seem to be practicable; however, careful consideration must necessarily be given to the specific design adopted. The ends of slightly cambered or bowed slabs could foul the extreme outside skids in a staggered arrangement and this hazard must be taken into account.

We have been fortunate at our Indiana Harbor plant in that skid marks have not been a problem with our particular combination of furnace capacity, heating practice, soaking time and pushing rate. We recognize, however, the industry-wide nature and seriousness of this problem.

H. H. Dineen: This matter of staggering the skids is very interesting; in fact, we are now building one furnace that has staggered skids. The real problem in staggering the skids is not mechanical; we can build them nearly any way that we desire. It is the difficulty in obtaining skid spacings that will suit the range in slab sizes.

There is usually such a range of sizes that it is very difficult to hold them on four skids, and when the skids are offset this problem is greatly magnified.

Is it the contact with the skid pipe which causes the greatest chilling, or is it the radiation shield effect of the skid pipe which has the most significant effect?

Dr. A. H. El-Waziri: In the case presented, the skids were shifted to a position midway between the original positions. At the start of this work, it was not known whether it would be necessary to shift the skids that much, but it seemed logical to go as far as possible from the original positions of the skids. However, further investigation may show that an offset of 11 in. would satisfactorily reduce the effect of the skid marks. This would alleviate, at least partly, the problem of supporting slabs of various sizes on the skids.

In this analysis it was assumed that radiation from within the furnace was such that the shielding effect could be neglected. However, the shielding effect can if desired be taken into account in the calculations. The relative significance of the effect of shielding and conducting heat to the skid will depend on the degree and extent of shielding assumed. ▲

Data Accumulation for Metal

Static switching devices can be used in heavy industrial applications which require high speed and reliability, without regard to the many problems which plague mechanical switching devices.

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A FLOOD of technical publications is sweeping the world! Words, definitions and ideas are being coined and invented faster than they can be read and understood by most men. This seems to be especially true in the world of science. The scope of this article is concerned with the automatic counting and recording of the occurrence of selected events in the process of finishing steel. In this subject, then, "data accumulation" means the counting and recording of certain events; and "processing lines" refers to finishing processes applied to steelmaking. The facts presented here may equally well be applied to other materials, where applicable.

Data accumulation in general is by no means a new subject. This art has been practiced for centuries. The records that have been kept by all people are data accumulation. The thing which draws particular attention to this subject in recent times is scientific advancement in both the art of providing means of data accumulation and the art of using this data. In the ultimate end, use of these modern techniques must be justified by a combination of product quality, product cost, product demand and competition.

A clear understanding of how a modern system for data accumulation operates and what uses may be made of it, may be illustrated by a simple yet practical application. The operation of a coil preparation processing line may serve to inspect the strip for defects, repair damaged edges by side trimming, rewind and build up coil size for further processing.

Generally, inspection in this process consists of the detection of pinholes and the determination of off-gage defects. Note should be made that qualitative or analog quantities are not being recorded. All input signals are of a go, no go character. The detection circuits are preprogrammed to establish the existence of acceptable or nonacceptable product. By accumulating such information, an operator may judge whether or not he should continue to build up his coil to obtain an acceptable percentage of prime material.

Present practice is to use "one ft" as the unit of linear measure. The presence of one or more defects in any part of a linear ft is considered to be a defect ft. A ft of material without any defect constitutes a prime ft. Perhaps the ft unit is used for data accumulation because: (1) certainly it is the unit that has been in use for many years, and (2) modern data accumulation apparatus can readily respond to and record these intervals at line speeds of several thousand fpm. Data accumulation has existed in mills for years on low rate of event type of processes, in the form of direct or solenoid —operated mechanical counters. It is not likely that such systems would operate successfully on high-speed lines on a ft basis, but possibly could be used if the unit interval was 100 ft.

As previously indicated, it is apparent that readout information must be quickly and accurately presented to the line operator, upon demand, in the form of a visual display and or some form of typed or punched card permanent record. Total prime and defect footage will be required. A calculation of per cent prime would be desirable.

To summarize the problem thus far, we have established:

1. Information handled:
   a. Inspection rate—of the order of 4000 fpm.
   b. Unit interval of measure—one ft.
   c. Inspect for:
      (1) Pinhole defects.
      (2) Material gage classification.

Processing Lines

2. Input signals:
   a. All are digital.
      (1) May originate as analog, but are entered into data system as digital.
3. Readout:
   a. Visual indication.
   b. Permanent record.

In addition to the foregoing requirements, a checking system in some form would be desirable, to confirm and help in locating trouble when output results are questioned.

Recent developments of components for electrical circuits have made it possible to build apparatus which performs the equivalent function of the opening and closing of a relay contact at very high speed. Relays cannot operate at the speeds required here. Data accumulation systems have been made using relays. The present-day telephone dial and switching system might be considered an example. The now common and well known transistor, in one of its many special forms, along with a resistor network, performs the basic switching circuit equivalent to that of a relay. This device switches very rapidly, without any significant deterioration, and at conveniently low power levels.

Specific reference is made to the transistor circuit known as "NOR" and is the basic unit circuit used to build all unit devices described here. The circuit detail is shown in Figure 1. Without technical explanation, it functions such that with no voltage signal on any of its input terminals, an output voltage will appear on its output terminal. This basic circuitry is shown as static switching. Figure 2A indicates its representation as used on schematic diagrams. Figure 2B illustrates its approximate equivalent as a relay. For those familiar with relay circuitry, but not yet accustomed to thinking in terms of NOR circuitry, this comparison will be helpful in following the basic logic circuits. When NOR circuit logic elements are used in sytems as illustrated here, it is possible to draw schematic diagrams in such a manner that the circuit representation is not completely foreign to those of conventional relay circuits. This is mentioned so those that see static switching circuit representation for the first time will not feel hopelessly lost.

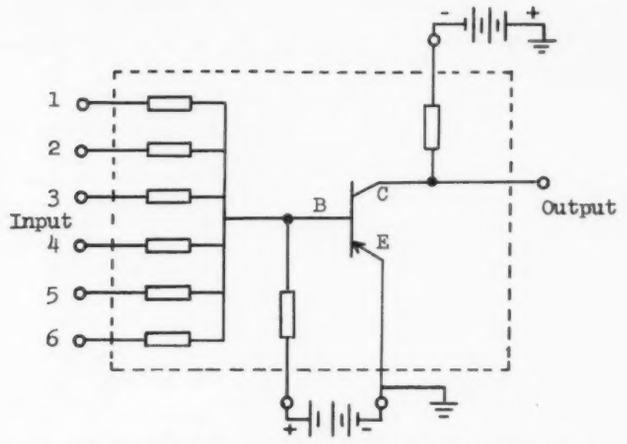


Figure 1 — The transistor NOR circuit is the basic unit.

To study the operation of such a typical system, refer to the signal flow block diagram shown in Figure 3. This diagram shows blocks of basic apparatus which needs clarification. As the signal flow is traced, these basic blocks are discussed in detail.

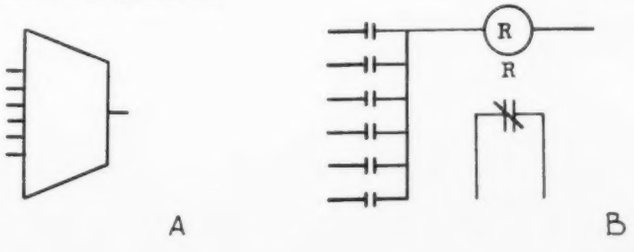
A signal must be generated to accurately indicate the passage of each ft of strip. This must be an electrical pulse of certain definite characteristics. Device A is accurately driven by the strip and calibrated so that a known number of pulse counts represents one ft of strip passage. The pulse shape and amplitude is independent of line speed, even down to zero speed. The oscillator, shaper, and counter (B) is calibrated to put out one pulse for each ft of strip passage. It must be pointed out that ft pulses may be generated by other devices which are not in contact with the strip.

The footage signal now generated represents total footage and is one of the pieces of data to be stored. The flow chart shows this signal going to total footage counter (G). Likewise, it is desirable to have a visual display of total footage as shown in block (K).

All counters make use of the NOR static switch. Usually the numbers to be handled have a maximum range of five digits (0 to 99,999) for most steel mill applications. This constitutes five decades, or five groups of numbers ranging from zero to nine. All decades of all counters can therefore be duplicate pieces of apparatus.

Count memory can be accomplished in many ways. Convenience of representation, ease of handling and the amount of apparatus required partially dictate the system to be used. In this case the binary coded decimal will be described. It is customary to think and manipulate figures by the decimal system. This system is preserved here for operator convenience. With respect to equipment and circuitry, straight binary systems are desirable.

Figure 2 — Schematic representation shows NOR symbol and relay equivalent.



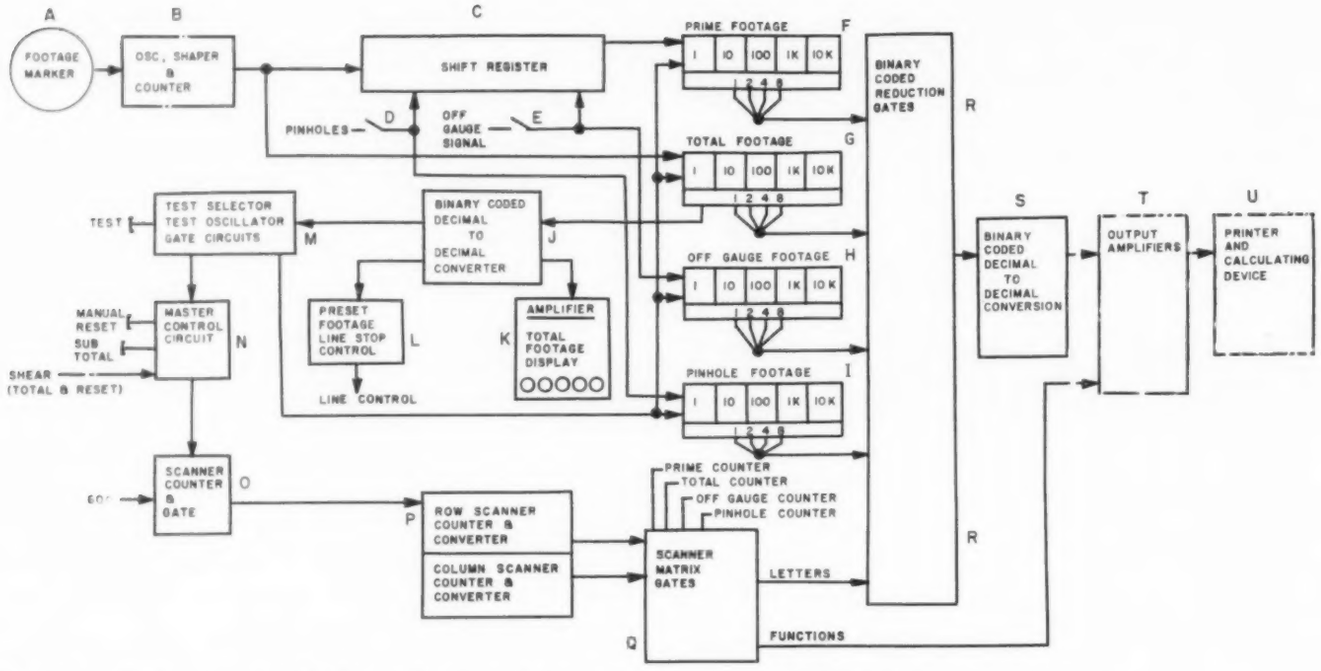


Figure 3 — Basic apparatus blocks can be grouped together to assemble required data from many sources.

In the binary system, any decimal number may be represented by the sum of the terms 2^0, 2^1, 2^2, 2^3, etc., some being present and others not being present. Thus, the decimal number 13,343 may be represented by the binary number 11,010,000,011,111, where "1" indicates the presence of a binary term and "0" indicates the absence. Reading from left to right, this means $2^{13} = 8192 + 2^{12} = 4096 + 2^{10} = 1024 + 2^4 = 16 + 2^3 = 8 + 2^2 = 4 + 2^1 = 2 + 2^0 = 1 = 13{,}343$. Likewise, binary 11,111,111,111,111 = 16,383.

It will be noted that binary representation is either one of two states,"1" or "0". This may be likened to a relay contact either being open or closed. From the example above, it follows that if we had 14 relay contacts it would be possible to represent any number from 0 to 16,383 and the use of a 15th relay would extend the range to 32,767, a 16th to 65,535, and a 17th to 131,071. Thus 17 contacts are required to represent the five digit number, 99,999, previously mentioned as a maximum requirement. Observe how unconventional and unhandy the straight binary system would be to a process line operator having to envision a decimal number in binary form.

Note that the first four binary numbers cover the range 0 to 15 and the first three cover the range 0 to 7. It follows then that we could make use of five groups of four binary numbers each, to represent any number from 0 to 99,999. Each group of four represents a decade of a decimal number. Specifically, in the following five series this would be 1, 2, 4, 8; 10, 20, 40, 80; 100, 200, 400, 800; 1000, 2000, 4000, 8000; and 10,000, 20,000, 40,000, 80,000. This is the binary coded decimal. Such an arrangement makes it possible to provide an operator with decimal reading equipment, but operate in a binary mode. Obviously this now requires 20 contacts, but the straight binary required 17. At the expense of three additional contacts, a convenient compromise appears.

Note should be made in the binary code, shown in Figure 4, a unique sequence of changes occurs in the progression of binary numbers. In the binary column 1, the signal appears at regularly spaced intervals; also this regularity appears in the 2, 4, 8 and 16 columns. This regularity may be described: at the time when one binary number switch changes from on to off, the next higher binary number switch changes state. This

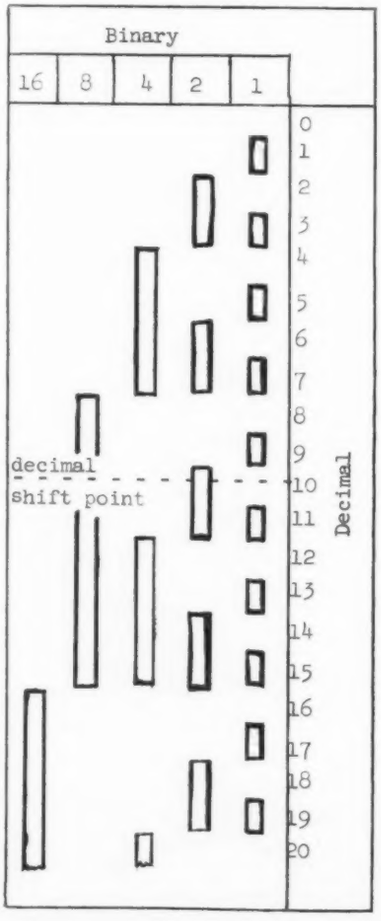


Figure 4 — Binary code pattern must be understood before a logical triggering circuit can be designed.

pattern may be recognized in the chart shown here. The pattern is important from the standpoint of designing a logical triggering circuit.

This table is shown as a straight binary system. For the binary coded decimal system, the presence of signals 8 + 2 would cause one decade to reset to zero and trigger a pulse into the next decade. This is indicated in Figure 4 at the line marked decimal shift point.

For convenience, a small binary coded decimal tabulation is given in Figure 5.

The counters in blocks (F), (G), (H) and (I) of Figure 3 are made of standard binary counter modules. When the count in one decade reaches ten, it transmits a pulse to the next decade and resets itself to zero.

We must now account for defect footage of two kinds, pinholes and off gage. These defects are detected by separate instruments and give a signal each time a defect occurs. A signal from the pinhole detector, (D) feeds to the pinhole counter (I) and by use of a memory device, the first pinhole signal in any ft triggers the counter and blocks signals of any additional pinholes in that ft. At the end of the measured ft, a ft pulse signal resets the memory, ready to accept the next pinhole signal. The off-gage counter functions in a similar manner.

Prime footage must indicate strip with no defect of either kind in the same ft of strip. The detecting instruments, pinhole and gage, because of their physical size and construction, cannot scan the strip in the same precise spot at the same time. The instruments may be separated by five to ten ft. It is necessary to correlate the location of one defect pinhole ft with respect to one defect off-gage ft, and at the same time transport this correlation to the strip shear, the data reference point. The shift register (C) provides this function.

The shift register likewise makes use of the same NOR static switch. In effect, one switch is used for each ft of shift required. The connection of the pinhole signal (D) to the shift register with respect to the register output corresponds exactly to the physical distance between the pinhole detector and the shear; likewise, the off-gage signal (E) is registered with respect to the shear. This device may be likened to a tube filled with white balls, one ball for each ft. The white balls are inserted by the ft measuring systems (A) and (B). When a pinhole occurs, it removes the white ball at the point of pinhole detection registry and replaces it with a black ball. This ball advances along the tube with the white balls, ft by ft, until it is at the off-gage detector input. The black ball has advanced exactly the way the strip has moved. If an off gage occurs in the same ft, the ball will not be changed, because it is already black. Otherwise, the gage detection registry unit would have removed the white ball and replaced it with a black ball. These balls continue to the end of the tube where the white balls cause counts to be stored in the prime footage counter (F) and the black ones are discarded. Thus, the prime footage counter has counted only footage which has no defect of either kind.

As an optional aid to the operator, it is very easy to incorporate a system to sound an alarm, slow down or stop the line when any of the counters, usually the total footage counter, reaches an easily adjusted preset footage count (L).

Binary coded decimal												Decimal
800	400	200	100	80	40	20	10	8	4	2	1	
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0	1	0	2
0	0	0	0	0	0	0	0	0	0	1	1	3
0	0	0	0	0	0	0	0	0	1	0	0	4
0	0	0	0	0	0	0	0	0	1	0	1	5
0	0	0	0	0	0	0	0	0	1	1	0	6
0	0	0	0	0	0	0	0	0	1	1	1	7
0	0	0	0	0	0	0	0	1	0	0	0	8
0	0	0	0	0	0	0	0	1	0	0	1	9
0	0	0	0	0	0	0	1	0	0	0	0	10
0	0	0	0	0	0	0	1	0	0	0	1	11
0	0	0	0	0	0	0	1	0	0	1	0	12
0	0	0	0	0	0	0	1	0	0	1	1	13
0	0	0	0	0	0	1	0	0	1	1	1	27
0	1	0	0	0	1	1	0	1	0	0	1	469

Figure 5 — The binary decimal system permits use of simple decimal reading equipment which provides operator information.

The master control block (N) contains circuitry for both automatic and manual initiation of the starting and stopping of all accumulation sequences.

Up to this point we have been concerned with the storage of appropriate data in each of the counters. Only one counter, the total footage counter, has displayed its results. We must now read out and print in some form the data stored in all counters, make a calculation of prime footage divided by total footage, and print that result expressed in per cent.

Readout is accomplished by a systematic scanning of each of the four binary number static switches in each decade of each counter. The state of each static switch (0 or 1) determines the information forwarded to the binary coded reduction gate (R).

The rate of scanning is established by a pulse generator (Q). This unit uses the 60-cycle line supply and reduces the pulse frequency by a counter so that a pulse output is provided at the desired frequency.

The scanning pulse causes a "row and column" matrix to advance point by point so that each row and column intersection is selected in an orderly manner for a definite length of time. There must be as many points or intersections in this matrix as there are events to occur in the complete readout program. As indicated in block (Q), the scanning program includes reading the counters, reading out certain prewired letters, reading out programmed instruction information and inserting time delay intervals where required. In reading the counters each 1-2-4-8 binary combination is read out as one word and transmitted as a decimal number to the printer.

The binary coded reduction gate (R) is simply a means of reducing the multiplicity of wires carrying all of the stored and programmed information into a 4-wire cable giving a binary 1-2-4-8 output combination.

Coming out of the reduction gate (R) and into the

conversion unit (S) is a binary signal which represents each one of the accumulated data digits, the prewired letters, and the operation signals to the printer calculator. This binary code must be changed to a decimal equivalent. The binary coded decimal to decimal converter, block (S) provides this function.

The printer calculator is solenoid operated and the low level energy signals are amplified in unit (T). The printer calculator (U), not only is instructed, as part of the scanning program, to print out the accumulated data of the counters, but also to re-enter some of the information, make a division operation and print out a calculation of per cent prime footage.

Electrically, all information could be read out in less than five sec, but due to limitations within the mechanical printer, about 15 sec are required to enter and print out the basic information, at which time the counters are available for storage of new or additional information. The calculator requires approximately an additional 15 sec to make the division and print out the final results. Printing is done in the form of adding machine tape presentation.

In the event that the printed out results appear questionable, a test may be initiated by the operator. The test consists of pulsing all counters from a 10-kc source. Feedback from the total footage counter feeds through a test digit selector switch such that when all digits of the total footage counter reach the value selected by the selector switch (adjustable 1 to 9), the test pulses stop. Complete readout and printing proceeds automatically. Since all counters received the same number of pulses, the readout of each counter should be identical. A quick observation of the printed record will reveal if the equipment has functioned properly.

The foregoing discussion concerns a relatively simple data accumulation system. Technical details of many of the electrical circuits, components and problems have been purposely omitted. It is intended here to provide a basic understanding of what data accumulation is, what it may be used for and one approach to a line of equipment which will provide this service under the heavy duty, industrial mill conditions.

From this basic presentation, one should be able to envision the possibilities of this system when extended into radically more complex forms. Nevertheless, the NOR static switch is used as the same fundamental unit, and the necessity for the basic functional blocks and their operation remain the same as described. Different forms of printout have advantages under certain circumstances. It may be desirable to include a punched tape immediately ahead of the printer to increase the reliability and to shorten the length of time that the counters are not available for accumulating data during readout. Storage may be added so the counters may be read out and made available for further use almost immediately.

In some cases, it may be justified to rearrange the apparatus so that, instead of using decade counters, it becomes a computer in which many complex calculations may be made and the program and results stored in a magnetic core storage plane. It is possible to use the results of computation to feed back into the process.

As an example of a more complex data accumulation system that may be desirable for tinning line operation, consider the possibilities:

1. Enter line statistics semi-automatically, such as line identification number, date, time, turn, operator, etc.
2. Enter coil statistics by punched card: diameter, strip width, strip thickness, top and bottom plating thickness, etc.
3. The width and thickness can be verified by gages, and alert the operator if the card information does not agree with the actual strip measurements. The plating control can be programmed and regulated to produce precise tin deposition.
4. Computation and readout possibilities are almost endless; for instance: coils per day, coils per turn, average time per 1000 ft, total running time per day, individual total footages of prime and all types of defect, per cent footage calculations, per cent prime per turn, tons per hr, lb of tin used per hr, plating efficiency, etc.

The use of a computer in a data accumulation system opens the door to many possibilities.

This discussion has indicated readout only at the end of the coil, but the possibility must be considered that a sub-readout of data at regular footage intervals might prove necessary in subsequent processes. This process of intermediate readout is known as coil profiling. This produces a profile of coil data with respect to some reference footage mark. The location, and therefore the distribution of frequency, of defects becomes known.

Today, considerable emphasis seems to be placed on the application of data accumulation equipment to electrolytic tinning lines. Data accumulation systems certainly can be applied to other types of metal processing lines, and no doubt we will see this done as soon as the understanding of the art of data accumulation becomes more general.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

by A. P. DI VINCENZO, Manager, Control Engineering, Reliance Electric and Engineering Co., Cleveland, Ohio

ADJUSTABLE-SPEED D-C DRIVES

Individual consideration must be given to the many factors involved in the selection of the proper adjustable-speed d-c drive.

THERE are many systems available today for driving machines at adjustable speeds. The d-c motor drive system is one method, but it may be worthwhile to mention a few of the other methods in use today. The following are the most widely used systems:

1. Variable-pitch pulleys.
2. Other mechanical systems.
3. Eddy-current coupling.
4. Wound-rotor motors.
5. Adjustable-speed d-c drives.

VARIABLE-PITCH PULLEYS

The simplest mechanical device that has been used for years and is still widely used is the variable-pitch pulley. It employs a belt and two cone-shaped split pulleys for speed variation.

OTHER MECHANICAL SYSTEMS

A second classification is a number of mechanical systems, such as transmissions, speed reducers or increasers and similar devices. These devices require a shaft movement for control, and can all be controlled remotely by either pneumatic, hydraulic, or electrical control which, in addition, gives power gain.

EDDY-CURRENT COUPLING

The eddy-current coupling is a coupling mounted on an a-c induction motor. Control is obtained by varying the magnitude of the d-c electric field in the coupling, which is similar in construction to an electric motor, with the exception that it has an input and output shaft.

WOUND-ROTOR MOTORS

Wound-rotor motors have been used for a number of years for adjustable-speed control. The most popular methods today are those using saturable reactors and magnetic amplifiers in either the primary or secondary, such as on crane and hoist applications, those using tubes and resistors in the secondary, and those which convert rotor power back into shaft power by having a d-c motor on the same shaft.

ADJUSTABLE-SPEED D-C DRIVES

The most common adjustable-speed d-c drives in use today are:

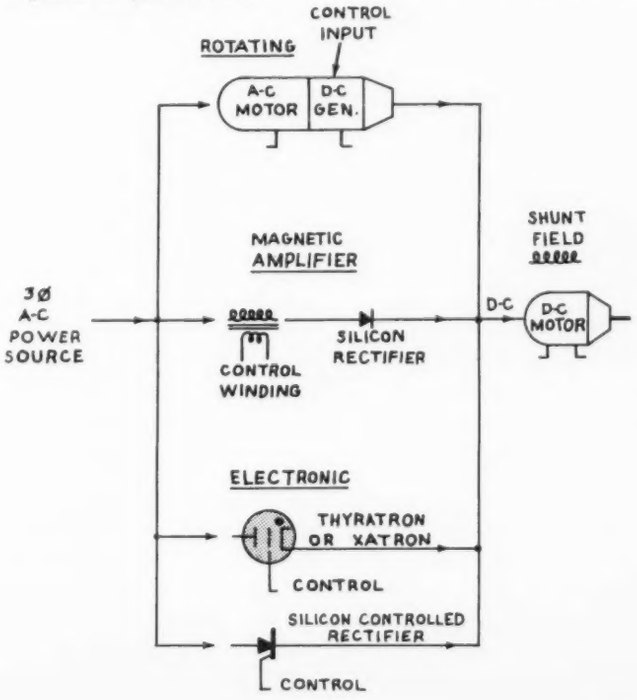
1. Rotating.
2. Magnetic amplifier.
3. Electronic.

Figure 1 is a single line diagram of the three drives showing the conversion means for each system.

The rotating system uses a motor-generator set, consisting of an a-c induction motor and a d-c generator. A 2-bearing construction is commonly used for economy and compactness. Control is obtained by varying the magnitude of either the generator field or the motor field excitation.

The magnetic amplifier system uses iron-cored reactors, which are similar in construction to a transformer, and silicon rectifiers. The silicon rectifiers serve two purposes, connecting the reactors so they

Figure 1 — Schematic shows three most common types of adjustable speed drives.



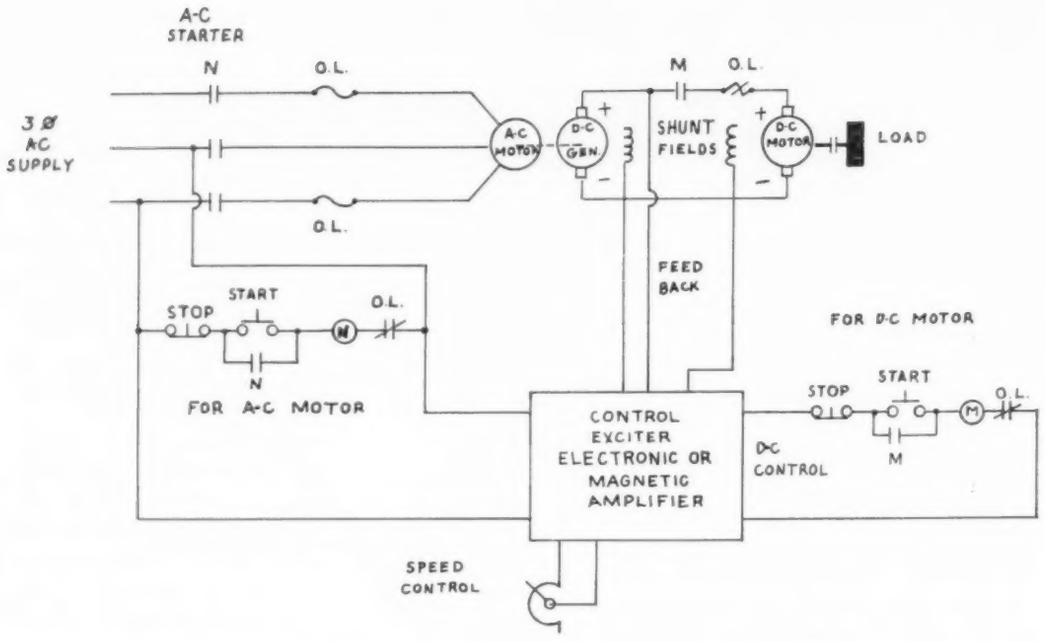


Figure 2 — The rotating drive unit is quite flexible in that its speed is internally controlled by regenerative braking action.

will operate as magnetic amplifiers for increased power gain and rectifying alternating current to direct current. Control of the output is obtained by varying the d-c magnetization of the reactor core.

In the electronic system, a gaseous rectifier tube such as a thyratron, excitron or ignitron is used both to rectify and control. Control is obtained by applying a very small amount of power to the grid or igniter so that the tube fires or conducts current only over a portion of the a-c cycle as required.

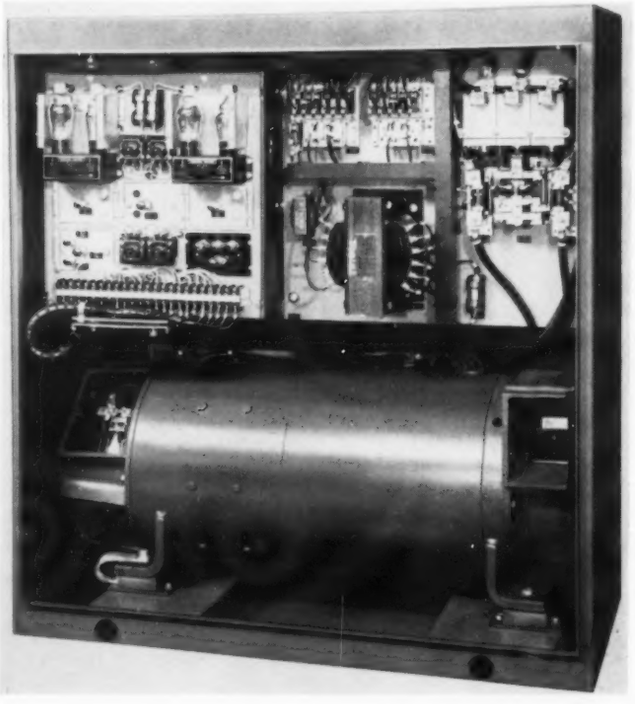
Rotating system—Figure 2 is a simplified schematic of the rotating drive system showing in more detail the components and elementary circuitry. The a-c induction motor used to drive the d-c generator requires a starter, pushbuttons and an overload relay. The d-c motor has an overload relay, an "M" contractor and pushbuttons for stopping and starting the drive. The control exciter supplies excitation to both generator and motor shunt fields; it has timed acceleration for controlling the rate of acceleration and deceleration of the motor. A speed control potentiometer sets up a reference voltage, and the generator voltage is taken as feedback, thus regulating the armature voltage.

Adjustment of the speed control adjusts the magnitude of the generator field, setting the voltage at the generator terminals and the motor armature. With a set value of motor shunt field, this determines the speed at which the motor will run.

An outstanding feature of the rotating system is its ability to reverse power flow. If the drive is running at a set speed and it is desired to decrease speed or stop, the generator shunt field is reduced in magnitude, calling for a lower speed. The voltage on the generator quickly decreases, but due to motor and load inertia, the motor tends to continue running at the same speed. The cemf in the motor then exceeds the generator voltage, producing a current flow from the motor to the generator. This reverse current runs the generator as a motor, which overdrives the a-c motor and pumps power back into the a-c line. This inherent action, called regenerative braking, continues until the motor cemf (plus IR drop) approximately equals the generator armature voltage. The motor is tightly controlled, since it is forced to run at a speed at which its cemf is approximately that of the voltage of the d-c generator which is directly under control.

A distinct application advantage of this system is its adaptability to process lines where a web of material is being processed through a number of sections, each being driven by a separate motor. The motors can be grouped together as required. Since they are all supplied by one generator, the same type of control for both acceleration and deceleration of the line, braking for payoffs, etc., is easily obtained. This is inherent in this

Figure 3 — Use of the 2-bearing motor-generator set permits relative compactness in the construction of rotating drive units.



drive system, and is obtained without complexity of control. Figure 3 illustrates a rotating drive, showing the 2-bearing motor-generator construction, the controlled exciter and the a-c starter.

Magnetic amplifier—The magnetic amplifier drive is relatively new in the drive field, having been introduced about two years ago. Although magnetic amplifiers have been used for over a decade for industrial control, their use for controlling d-c motor armature power had been rather limited until the introduction of a practical silicon rectifier. Selenium rectifiers previously available were too costly and too large for this application.

Figure 4 is a simplified schematic of a typical magnetic amplifier drive showing the major components and elementary circuitry. The drive consists of a circuit breaker, an a-c starter in the a-c supply line which feeds a 3-phase bridge made up of a silicon rectifier, reactor power windings, and a special quick-acting fuse in each of the six legs of the bridge. The output of the bridge supplies d-c to the drive motor. The a-c starter is used to start and stop the drive. Note that the d-c contactor required in the rotating drive is eliminated. Control is obtained by using a magnetic amplifier to control the a-c windings on the main power magnetic amplifier. A speed-control potentiometer sets up a reference voltage for the preamplifier and the armature voltage is taken as feedback, thus regulating the armature voltage. Time limit acceleration is available similar to that in the rotating system.

The commutating rectifier, connected as a back rectifier, is also provided. It has a smoothing effect on the load current and assures proper reactor operation. It tends to make the d-c motor look like a resistor to the magnetic amplifier, thus preventing any instability of magnetic operation over ranges in which the motor appears as an inductive load to the magnetic amplifiers.

Three types of overload protection are necessary. These are the circuit breaker, the special quick-acting fuse and the d-c overload. This protection is required for the silicon rectifiers and must be coordinated. Silicon rectifiers are small devices with little energy storage, therefore, they have little overload capacity. A 160-amp d-c rectifier has a silicon wafer less than $\frac{3}{4}$-in. diameter and about 10-mils thick.

Moreover, these rectifiers are not adequately protected by conventional fuses. Figure 5 is a graph of the overload capacity of a typical silicon rectifier at a given temperature, cooling fin size and forced air flow plotted against cycles of 60-cycle current. For one cycle, the overload capacity is only 550 per cent of rating. No conventional fuse or circuit breaker is fast enough to catch this relatively low surge current rating, and a special fast-acting fuse is required. From two to three cycles, to one to two sec a circuit breaker is required to give ample protection. A d-c overload is sufficient for long-time protection of both the silicon rectifier and the motor. Silicon rectifiers are usually selected to give 200 per cent overload for ten sec and about 150 per cent overload for one min. By derating rectifiers further, it is sometimes possible to eliminate the circuit breaker.

Though current surges of 1 and 2-cycle duration are very unlikely from a load standpoint, since they are equivalent to practically a short circuit, quick-acting fuses will protect the silicon rectifiers against such a surge.

Silicon rectifiers must also be protected against transient peak voltages that may exceed the rated peak inverse voltage. These transients can come from either the a-c supply line side, as those caused by the switching on and off of a transformer, or the load side, as those caused by the switching of control contactors and relays. These transients are of very high frequency and can hardly be seen on ordinary oscilloscopes, but have been found to break down silicon rectifiers.

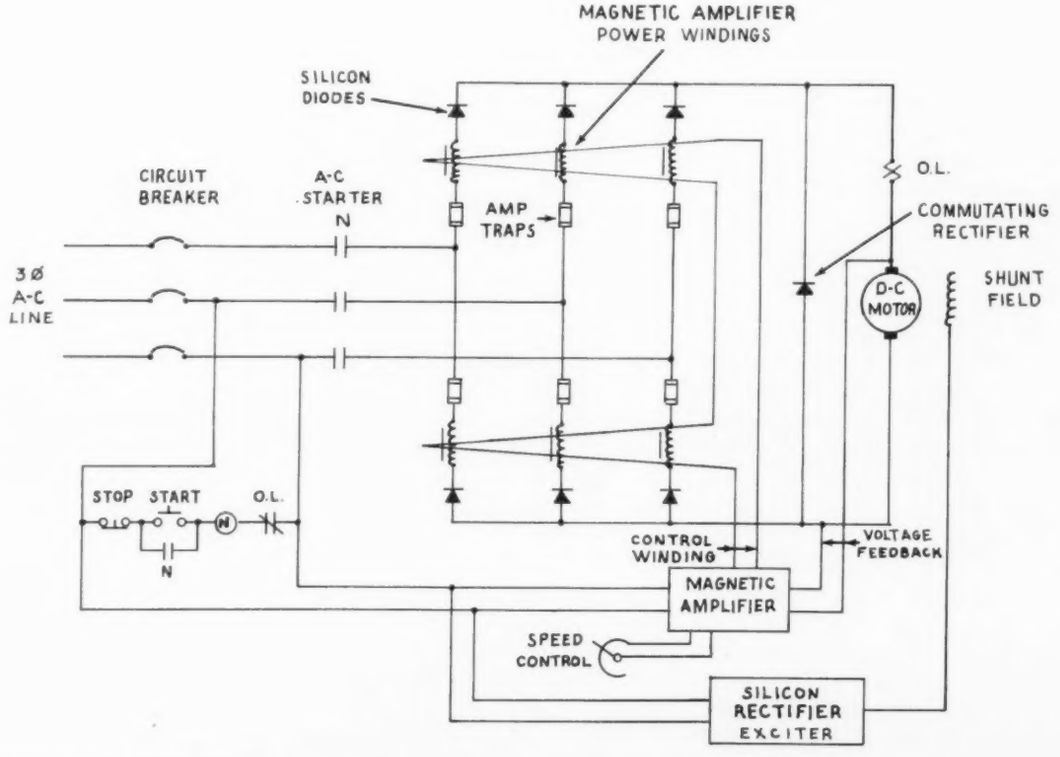


Figure 4 — Motor-field excitation of the magnetic-amplifier drive can be controlled by a silicon rectifier.

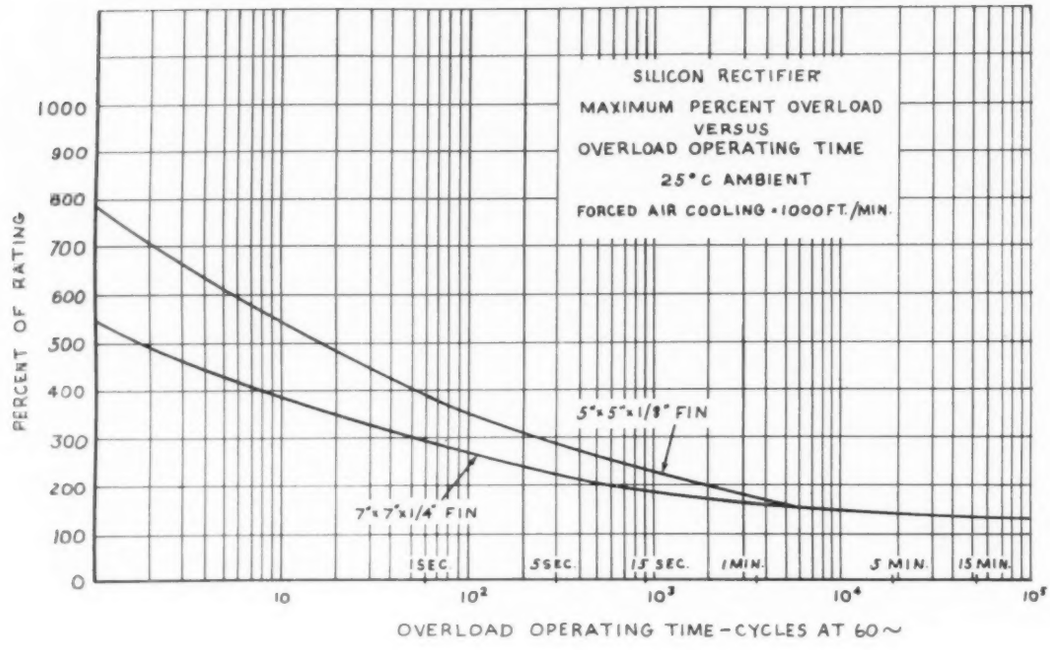


Figure 5 — Overload capacity for a silicon rectifier is rather low and rectifiers are chosen oversize to obtain the desired protection.

Resistance-capacitance filters or voltage surge devices must be used to protect against these transients. It has also been found that to protect against unknown transients, the silicon rectifier peak inverse voltage used should be about two times that required by the voltage of the a-c supply line. This leads to putting cells in series to build up inverse voltage ratings, which requires resistors across the cells to make them equally divide the reverse voltage, since backward cell resistance is not the same for all cells.

The control is arranged so that the motor is never disconnected from its magnetic amplifier power unit unless the a-c power is also disconnected. This is necessary because enough load is required to provide magnetizing current for the reactors. If the load falls below the magnetizing current, loss of control results, with the output voltage rising to a high value. The magnetic amplifier has a minimum load requirement that must be checked for each application. The range of hp must be within the limits of the range of the magnetic amplifier. A typical magnetic amplifier has a range of 15 to 1 over its linear portion, and 40 to 1 total range if it is overdriven in its nonlinear regions. Operation in the nonlinear region must be investigated, since the gain changes appreciably and can lead to system instability.

For best economy, 75-hp drives and above have both the silicon rectifiers and the magnetic amplifiers forced cooled to increase capacity. The magnetic amplifiers have at least an 80 C rise, while the silicon rectifiers are selected by taking cabinet heating into consideration.

For best economy in the design of the magnetic amplifiers, the d-c voltage output of the 3-phase bridge is approximately the same as the a-c supply voltage. That is, the ratio of alternating to direct current is approximately one to one. With silicon rectifiers alone, it is possible to obtain over 500-volt direct current with a 460-volt line. With reactors, which are connected in series with the line, an appreciable voltage drop exists even when they are fully saturated; hence, a lower output voltage is available. The size of the reactors does not influence this drop as much as the magnetic material used in the reactor. Square loop material, which is also more expensive, gives a lower drop.

The voltage of the d-c motor must be selected so that it will operate over the a-c voltage range. For a 460-volt a-c line, a 480-volt d-c motor is typical, and for a 230-volt a-c line, a 240-volt d-c motor can be used. For some applications requiring a higher ceiling voltage for forcing, etc., 400 and 350-volt motors have been used with 460-volt a-c lines. Lower d-c motor voltages may have to be used if the a-c supply line is constantly lower than required. If the a-c line voltage drops too low, or if a 240-volt standard motor is to be used from a 460-volt supply, then a transformer or autotransformer must be used. Standard drives are designed for 460-volt a-c supply, but it is recommended that under ten hp, a 230-volt a-c supply be used, since 480-volt motors in this hp range are more difficult to design for good commutation. There is also a measurable degradation of motor commutating ability due to ripple in the d-c output of the rectifiers.

The rectifiers in the magnetic amplifier drive prevent reversal of direct current from the motor back to the a-c line as is possible with the rotating system. The motor must either coast down to a new speed or stop because of load friction. In some applications, the friction is enough for a fast stop. An alternative is slow-down dynamic braking, usually of more than one step, which has been used but becomes fairly complex and in most cases leads to a compromise of performance.

In selecting a magnetic amplifier drive, some precautions should be considered:

1. Applications which combine very low speeds with very light loads should be investigated individually to determine whether the range can be covered and the necessary speed regulation can be obtained.
2. Magnetic amplifiers will not absorb d-c power, and controlled deceleration then may require use of loading resistors or slow-down dynamic braking.

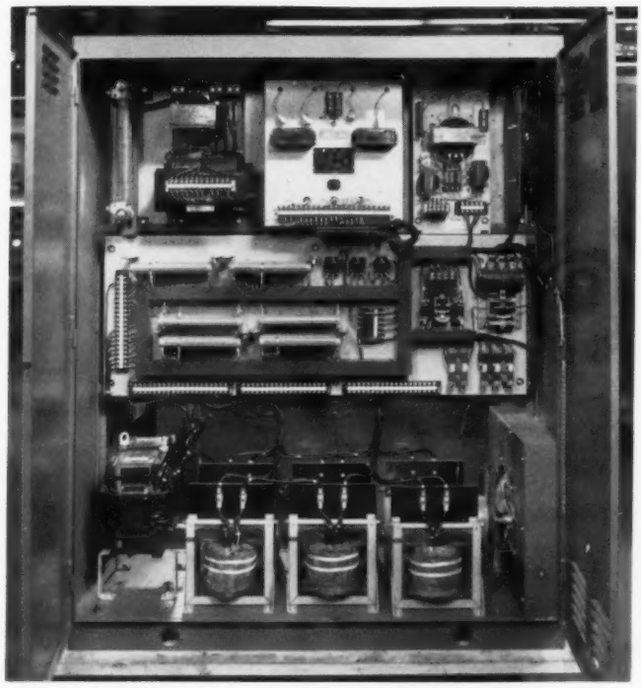


Figure 6 — Complex or relatively large magnetic drive units are fan cooled to increase their capacity.

3. If more than a single motor is used with contactors required in each armature circuit, precautions must be taken not to unload the magnetic amplifiers to prevent loss of control, and all transients caused by switching must be properly suppressed to prevent damage to silicon rectifiers.

Figure 6 shows a 30-hp drive, which is a little more complex than a standard drive because it is a 5-motor drive with more control functions.

Electronic drives—The electronic drive is also a static drive in that it has no moving parts in the conversion unit. The tubes are gaseous rectifiers for high current capacity. Thyratrons are used from fractional ratings up to about 25 hp. A thyratron employs either mercury vapor or xenon gas with a heated cathode. For the range of 30 to 100 hp, a mercury pool excitron tube unit as shown in Figure 7 is used. The grid control power is the same order of magnitude as that used on thyratrons. Above 100 hp, ignitron tubes have been used for years, especially on newsprint press drives. The igniter power required is many times that necessary to fire the grid of either thyratrons or excitron tubes.

Thyratron drives have been most popular in this country, while excitrons and ignitrons have been used successfully primarily in Europe. European drives are now appearing on the U. S. market.

The magnetic amplifier drive can be used to illustrate the circuit of a tube drive in the middle hp range, see Figure 5.

In the circuit of the magnetic amplifier, the magnetic amplifier can be eliminated entirely and three of the silicon diodes replaced with grid-controlled rectifier tubes. Control, then, is obtained by supplying proper grid voltages to the tubes. Other control features are essentially the same as described for both the rotating and the magnetic amplifier drive.

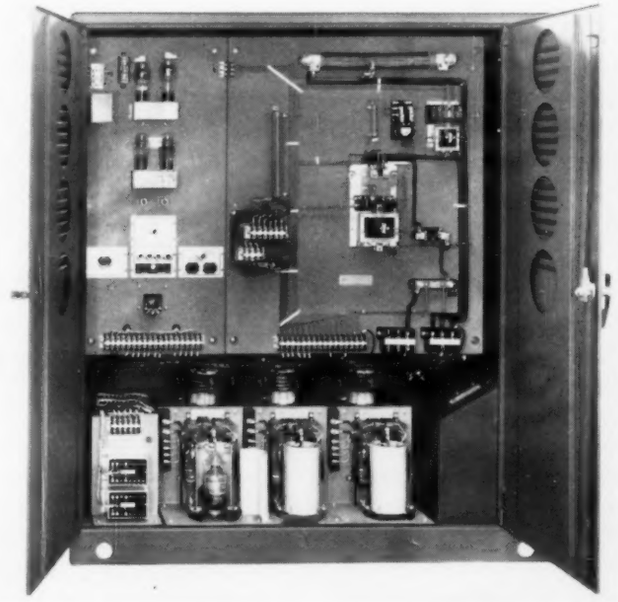
The electronic drive and the magnetic amplifier drive are similar in some respects. Both are static and do not have reverse power flow, as the motor-generator set does. However, the tubes used in the electronic drive are true switches which can completely cut off supply power. In addition, they have a lower voltage drop, so that a higher ceiling voltage can be obtained from a 460-volt a-c supply. On occasion 500-volt d-c motors have been used with 3-phase, 460-volt lines.

A new device which is being developed and gives promise to make electronic drives even more popular is the silicon controlled rectifier. It is similar to the silicon rectifier, but it has a third electrode which is equivalent to the grid of a thyratron. It operates like a thyratron, except that there is no heated cathode and the voltage drop is about 1.5 volts, compared to the 12 volts of thyratrons and excitrons, insuring greater efficiency. The controlled rectifier promises to have longer life than a thyratron, since it has no heated filament or gas.

Experimental drives have been built, but they are not ready for general use because of the following:

1. The present cost of silicon controlled rectifiers is high and only a few ratings are available.
2. The maximum peak inverse voltage available is 400 volts. With an appropriate safety factor, this means that the d-c motor voltages may have to be low. Units may be connected in series, but this leads to firing circuit complexities.
3. Unlike the thyratron, which is rated at average current, these units must be rated on rms. As an example, a unit rated at 16-amp d-c full conduction is only good for six amp at 30 degree conduction. This may not be a problem, since higher current units are being developed; but obtaining uniform current density in larger wafer silicon devices is a problem today.

Figure 7 — Mercury pool excitrons are similar to the multi-anode pool-type rectifiers long in use but employ a grid to control firing.



DRIVE COMPARISON

A table follows showing a comparison of the three drives described; rotating, magnetic amplifier and electronic. All comments are general statements, need

not be specifically true for a given hp or application, and are intended only as a "rule-of-thumb" guide based on experience, observation, and manufacturers' published data. For specific applications, it is best to consult a drive manufacturer or his local representative.

TABLE I
Adjustable Speed D-C Drive Comparison

	Rotating	Magnetic amplifier	Electronic
Speed range	2	3	1
Power range	2	3	1
Size	2	2	1
Weight	3	2	1
Cost	2	3	1
Maintenance	3	1	2
Speed of response	1	2	3
Efficiency	3	1	2
Noise	3	2	1
Overload capacity	1	3	2
Minimum load requirement	1	3	2
Rapid reversing	1	2	2
Overhauling loads	1	2	2
Quick stop, rapid deceleration	1	2	2
Process control flexibility	1	2	2

Speed range by voltage control—Electronic drives are available with 50 to 1 and even 100 to 1 speed range. Rotating drives can go to ten to one without too much circuit complexity, while eight to one is a practical limit on magnetic amplifier drives. Rotating and magnetic amplifier drives can cover an additional speed range of four to one by motor field control.

Power range—The electronic drive has the largest power range, since the tubes can be cut off completely, similar to opening a switch. The motor-generator set has residual generator voltage below which control range cannot be obtained. The magnetic amplifier drive has a limited power output range, since it is a series device with an appreciable voltage drop. The power range of the magnetic amplifier depends on the type of magnetic material used in the reactor.

Size—The electronic drive is the smallest of the three, since the tubes take less space than either the magnetic amplifier or the rotating unit. The rotating and magnetic amplifier drives are about the same when considering a 3600-rpm, 2-bearing motor-generator set as the rotating unit. Although the magnetic amplifier can be made to take up less floor space by stacking reactors, this is not always the best practical arrangement.

Weight—In weight, the electronic drive is the lightest, and the rotating drive the heaviest. The magnetic amplifier comes somewhere between the extremes.

Cost—The thyratron drives up to five hp are lower in cost than the rotating or the magnetic amplifier. At higher hp ratings all three are about the same. If a transformer must be used in the a-c supply, the magnetic amplifier drive definitely becomes more expensive than the other two.

Maintenance—In maintenance, the magnetic amplifier rates first, since theoretically its parts do not wear out. The thyratron drives will require tube replacements, but very long life should be expected from the mercury pool devices. The motor-generator set requires maintenance of commutator, brushes and bearings.

Speed of response—The electronic drives can respond to a signal change of one half cycle of the 60-cycle power supply, by far, the fastest response. The magnetic amplifier has a smaller control-winding time constant than the typical generator field, so that it is faster than the rotating unit.

The above comparison is the speed of response of the control devices themselves. When used in a practical drive system where speed of response in getting from one speed to another or maintaining speed due to load change is to be obtained as fast as possible, then the rotating drive can be made the fastest.

Practically all d-c drives today employ high-gain regulators with some kind of feedback. A speed change or load change gives sufficient error to cause the regulator to force the control device. With the rotating drive, the regulator can force in both directions; that is, on or off and the drive will follow due to regeneration. Neither the electronic nor the magnetic amplifier drive will follow in the off direction. They must coast and may take a long time to come to the final value, depending on load inertia and friction. The rotating drive will get to the final speed much faster. In practical drive systems, then, the rotating drive has the fastest speed of response. Rotating drives have been built that will accelerate a 500-hp motor to full speed in less than three revolutions of the shaft. Rapid reversing, overhauling loads, and quick stops are best handled by the rotating drive.

Efficiency—The magnetic amplifier, in most sizes, is the most efficient due to the low voltage drop of the silicon rectifiers, 1 to 1.5 volts. The magnetic amplifier I^2R losses are usually smaller than the tube losses, which consists of the 12-volt drop across the tube and heater losses on thyratrons. The rotating unit is a little less efficient due to the two power conversions.

Noise—The noise level of the electronic drive and the magnetic amplifier drive should be about the same unless there are magnetic noises in the magnetic amplifier. The rotating drive has more noise because of its moving parts.

Overload capacity—Because it has more mass, the rotating unit has more overload capacity, either peak momentary overloads or small long-time overloads. Momentary overloads on rotating drives may be as high as 400 per cent. The rectifying devices on the other two drives are smaller, which limit overload capacity.

Minimum load requirements—This is required only in the magnetic amplifier drive, since it is a series device.

Process control flexibility—Because of inherent reverse power flow, ease of multimotor operation and tight control, the rotating system is easily adapted for complex control schemes used in process control.

SUMMARY

Because of the performance characteristics described, there is no doubt that the rotating drive will be with us for some time to come. It is the most useful of the d-c drive systems. The electronic and magnetic amplifier drives are very similar to each other, except that the magnetic amplifier has more limitations. If the development of the silicon controlled rectifier proves successful, then it appears as though electronic drives using this device will replace the magnetic amplifier-type drives. ▲

Figure 1 — The largest sinter line in the world, capable of producing more than 250,000 net tons per month of high quality sintered ore charge for blast furnaces, has gone into operation at the Aliquippa, Pa., works of J&L. An operator is visually checking the operation of the ignition furnace, shown at the left, by noting the condition of the sinter bed as it leaves the furnace.

New Sinter Line Increases J&L's Blast Furnace Capacity

JONES & LAUGHLIN Steel Corp.'s new sinter plant at Aliquippa, Pa., is the largest single-strand installation in the world. Built by Dravo Corp. under a licensing agreement with the Lurgi Co., this machine has a grate width of 13 ft-2 in. and is 183 ft-9 in. long over the 14 wind boxes, for a total hearth area of 2419 sq ft. The plant has a design capacity of 8500 net tons per day of self-fluxing sinter.

The facility is also equipped with the world's largest circular cooler, to bring the temperature of the sintered product down from about 1450 F surface temperature to a heat level at which the sinter can be handled by rubber belt conveyors.

The cooler measures approximately 140-ft O.D. with a tray width of 12 ft. Effective cooling area is 3300 sq ft. Each of four centrifugal fans is rated at 330,000 cfm at 2¾-in. water column and a mean air temperature of 300 F.

An important feature of the plant is the automatic proportioning system for the sinter mix, which is made up of: ore burden; recycled fines; miscellaneous materials, such as limestone, dolomite, mill scale and flue dust; coke; and water.

Control stations for the system, which utilizes pneumatic type belt scales and controls, are located on the main control panel at the head end of the sinter machine. At the master ore burden station, the operator presets the total amount of ore to be included in the mix. He then manually sets the feed rate for recycled fines to match the amount desired. The recycled fines' feed rate always is set manually, then maintained automatically.

The ore burden is made up of varying amounts of four kinds of ore, basic classifier, bessemer classifier, Tracy and Benson concentrates and the operator must select the desired ratio of each type of ore to the total ore burden. These ratios are set at individual radio control stations, calibrated in percentages of the ore burden.

Limestone, dolomite, mill scale and flue dust are similarly fed into the mix through individual ratio control stations in amounts directly proportional to the master ore burden. The coke feed rate, however, is based on a ratio of the amount of coke to the total ore burden plus the recycled fines. Thus, while feed rates of the other additives will vary automatically when the master ore burden rate is raised or lowered, the coke feed rate also will vary automatically with changes in the recycled fines feed rate.

Water may be added at the mixing drum, the balling drums or both. Ratio control stations for each of these points permit the operator to set the desired percentage of water to total sinter mix and the water will be added automatically.

In the first step in the sinter plant's operation, raw materials are delivered to track hoppers by railroad hopper cars, ore yard transfer cars or self-propelled rubber-tired scrapers. A car shake-out is provided for unloading railroad cars.

Ore is fed from the hoppers by variable-speed apron feeders to a 42-in. wide belt conveyor system, rated at 1200 tons per hr. This, in turn, discharges to a 48-in. shuttle belt conveyor which uniformly distributes the ore to four surge bins.

Variable-speed roll feeders beneath the bins distribute the ore to four double-deck ¾-in. scalping screens, used under initial operations as single-deck screens.

Oversized material is conveyed to a loadout bin from which it can be loaded into railroad or transfer cars, while material passing through the screens is conveyed to one of seven 1000-ton ore storage bins for sinter mix feeding.

Miscellaneous materials—coke, limestone, dolomite, mill scale and flue dust—are fed from track hoppers by variable-speed apron feeders to another 42-in. belt system. After rubble screening on a 6 x 14-ft screen with 1-in. openings, all materials except coke are conveyed to their respective storage bins.

Screened coke is conveyed to three gunite-lined storage bins with a total capacity of 690 net tons. Electromagnetic vibrating feeders transfer the coke from these bins onto a conveyor system, which discharges into a rod mill with a binding capacity of 30 tons per hr. Minus ⅛-in. coke is discharged from the rod mill and conveyed by belt to two ground coke storage bins of 210 tons capacity each or to a loadout bin.

Provision also has been made for utilization of pre-ground coke. This is conveyed by the same belt system directly from the track hoppers to the ground coke storage bins, bypassing the rubble screen and rod mill.

The raw materials handling system and storage capacity are designed to handle all necessary material for a full day's production in a single eight-hour shift.

All but one of the 12 raw materials storage bins are equipped with steam coils, electric vibrators, manually-adjusted feed gates and 8 ft-6-in. variable-speed table feeders fitted with Ni-hard liner plates. The exception is the Tracy ore bin, which uses a 36-in. variable-speed apron feeder to feed the Michigan sticky-type ore.

The ore and limestone storage bin feeders discharge directly onto a 42-in. sinter mix conveyor belt of 625 net tons per hr capacity, which passes over a series of eight conveyor scales. The feeders for miscellaneous materials and coke breeze discharge onto four 30-in. weigh belts, then onto the mix belt. Hot and cold sinter fines are added on top of the mix prior to the primary mixing drum by a 30-in. apron feeder which is fed by the sinter fines bin table feeders.

The 12-ft diameter x 30-ft long mixing drum is located at ground level and is fitted with rows of 8-in. wide x 12-in. long x 1-in. thick mixing flights, spaced approximately 3 ft apart in each direction with the first two rows set at a 45-degree slope. The mixing drum can be bypassed, if desired.

Second-stage mixing and balling is accomplished in two 12 x 30-ft balling drums fitted with ⅜-in. thick x 2-in. wide longitudinal bars extending the full length of the drum and spaced approximately 8½ in. apart. These drums are located above and behind the feed end of the sinter machine. The total sinter mix is fed to the split hopper above the balling drums by a reciprocating car. Sufficient horsepower has been provided for either drum to handle the total mix singly, if necessary.

From the drums, the conditioned sinter mix is discharged onto twin conveyors mounted on a common reciprocating carriage, assuring uniform distribution of the mix into the roll feeder hopper. Conditioned sinter mix then is fed by variable-speed roll feeder to the sinter machine, and the bed is leveled by a manually-operated adjustable cut-off gate.

The surge bin over the roll feeder is mounted on load cells. A continuous level indicator and a high-low level alarm are located on the instrument panel. Speed of the roll feeder is electrically interlocked with speed of the sinter machine, with an additional trim control permitting manual adjustments in the feed rate. A selector switch may be used to either interlock the roll feeder with the sinter mix conveyor system or to disconnect the roll feeder and sinter machine so that the sinter mix system can be operated independently.

A hearth layer of ⅜-in. x ¾-in. sinter is conveyed as required from the cold sinter screens to a hearth layer bin located above the feed end of the sinter machine. Layer depth may be varied from ½ to 3 in. but normally is approximately 1 in.

The Dravo-Lurgi ignition furnace is composed of four units, each with its own carriage to permit easy handling by overhead crane, and consisting of a welded steel shell and a rammed-type refractory lining. These units bolt together to form the complete furnace. Total heat input is 150,000 Btu per ton of sinter product at 8500 tons per day, and the furnace is equipped with two combustion air blowers, one serving as an auxiliary. Each blower is rated at 12,000 cfm at 21-in. water column.

The continuous strand sinter machine is 215 ft-4 in. long from center to center of the sprockets. Speed of the strand may be regulated from 6⅔ to 20 fpm.

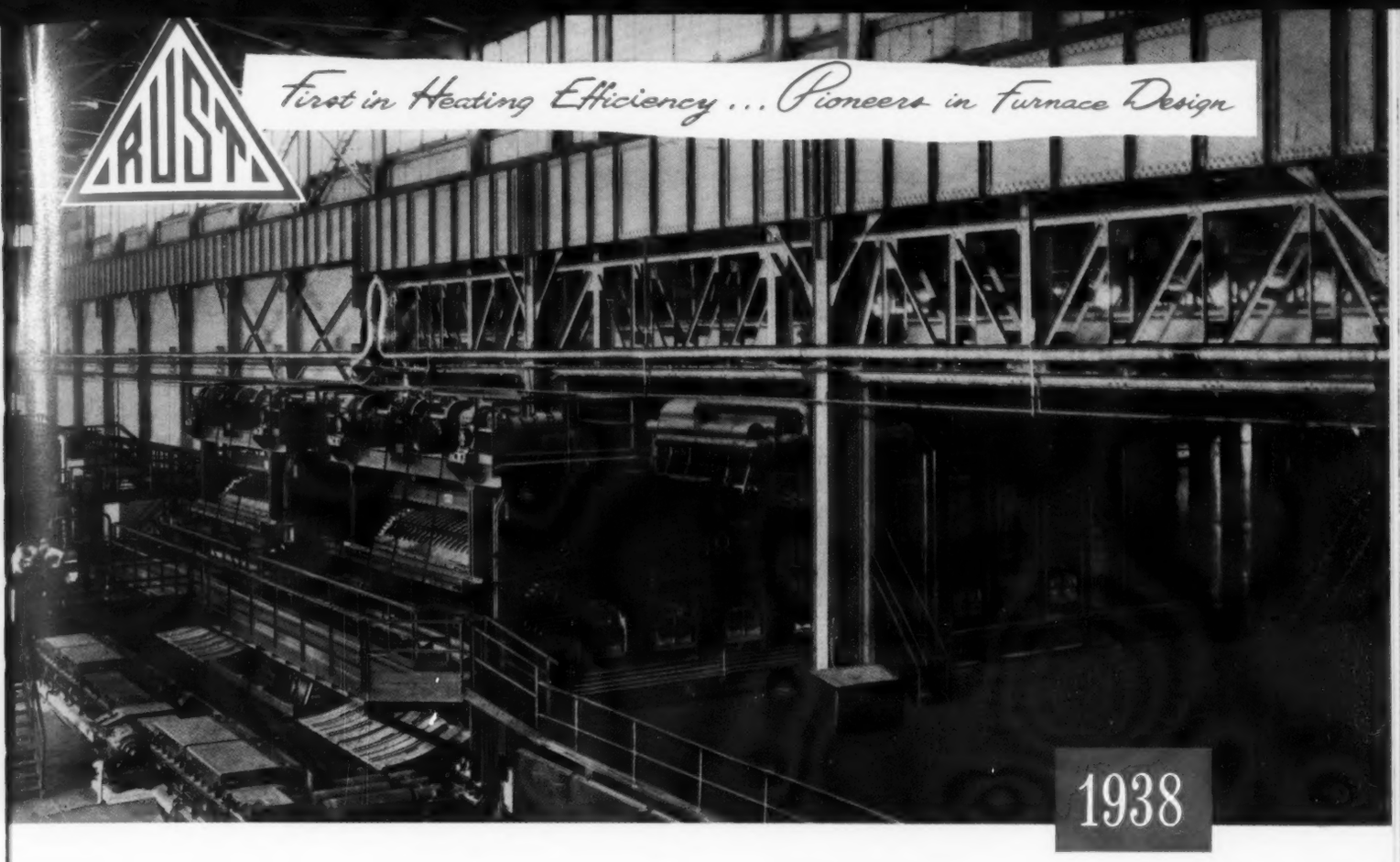
Design of the machine's drive eliminates rubbing of the pallet ends. Pallets are lifted around the drive end curved track by two sprocket wheels that engage rollers on the pallet axles. Spacing of the sprocket teeth prevents the pallet faces from rubbing each other as they are lifted from the bottom to the top strand. At the top of the drive each pallet is prepositioned in a horizontal plane before the thrust of the strand is imposed upon it.

The sprocket wheels are joined by a torque tube and mounted on a common shaft with one wheel keyed to the shaft and the other free. An adjusting plate on one sprocket wheel permits movement of that sprocket independently of the other for precise alinement.

The drive shaft is driven by an overhung helical gear and pinion, driven through a flexible coupling by a reducer. Power for the reducer is through V-belts from a 40-hp, 575/1750-rpm, 230-volt d-c motor. A shear pin in the high-speed V-belt sheave protects against possible jamming or overload. Connected to a sprocket on the stub end of the high speed shaft is a zero speed switch interlocked with the controls of the plant.

At the discharge end of the machine is a counterweighted tipping wheel designed to eliminate pallet wear as the pallets are conveyed from the top strand to the bottom strand. Hung from a double-hinged hanger, the tipping wheel is counterweighted to maintain contact with both strands.

Of three-piece reversible cast steel construction, each of the 96 pallets holds four rows of heat-resisting, alloy finger-type grate bars. Pallets are mounted on four 11¾-in. diam-



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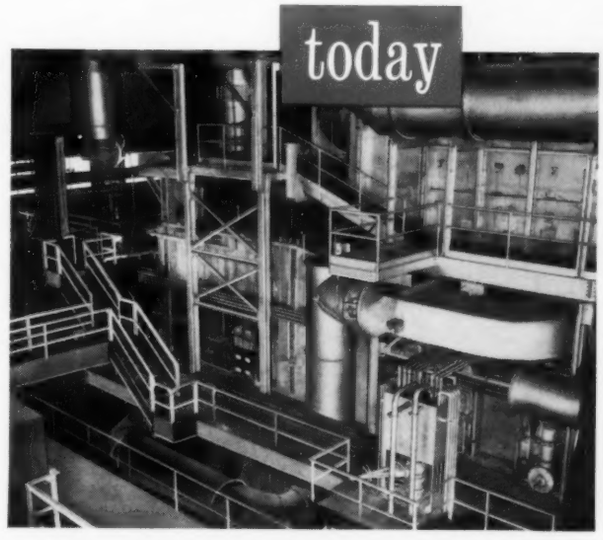

Modern four-zone continuous furnace for heating slabs at a large eastern steel mill.

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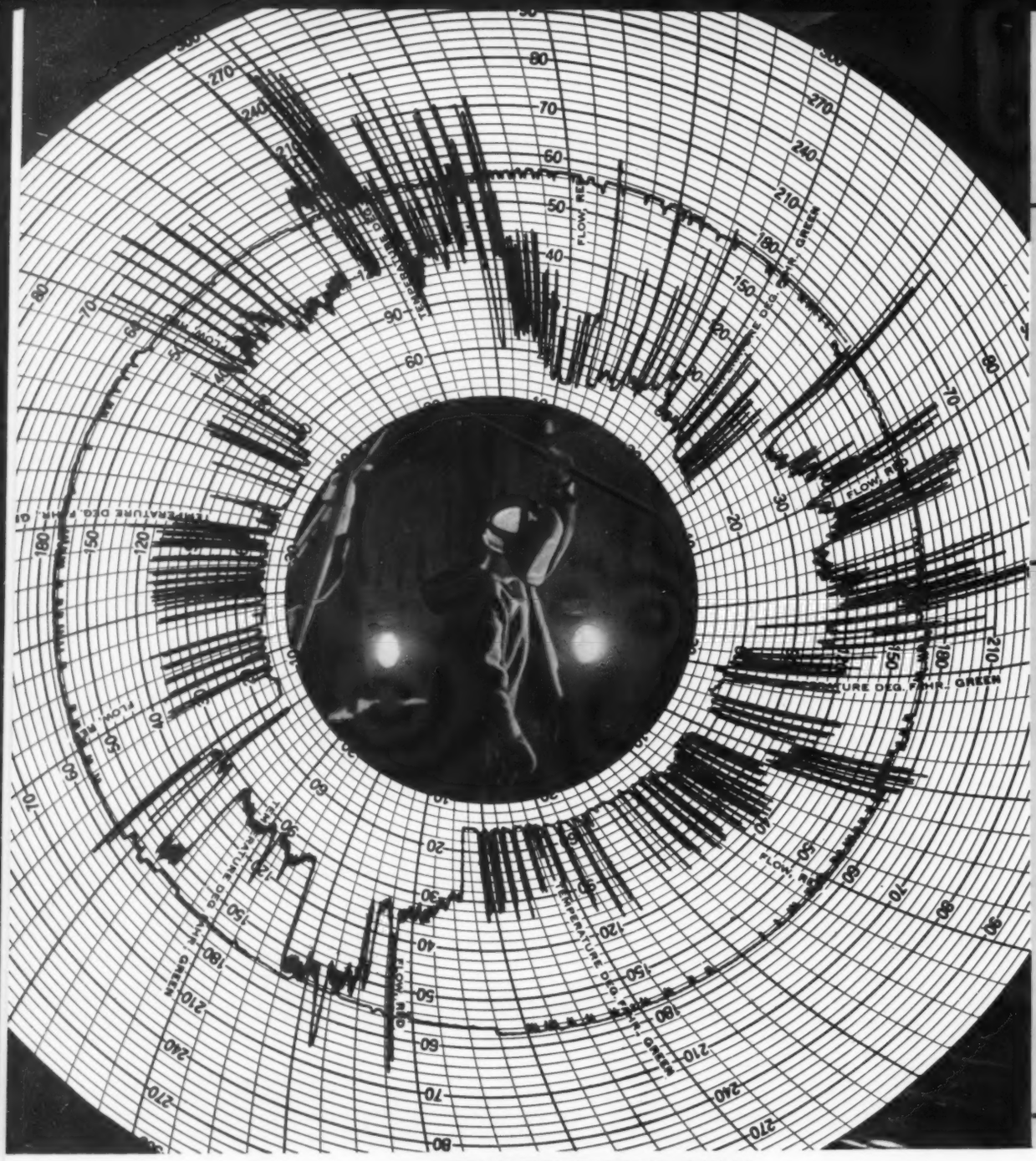

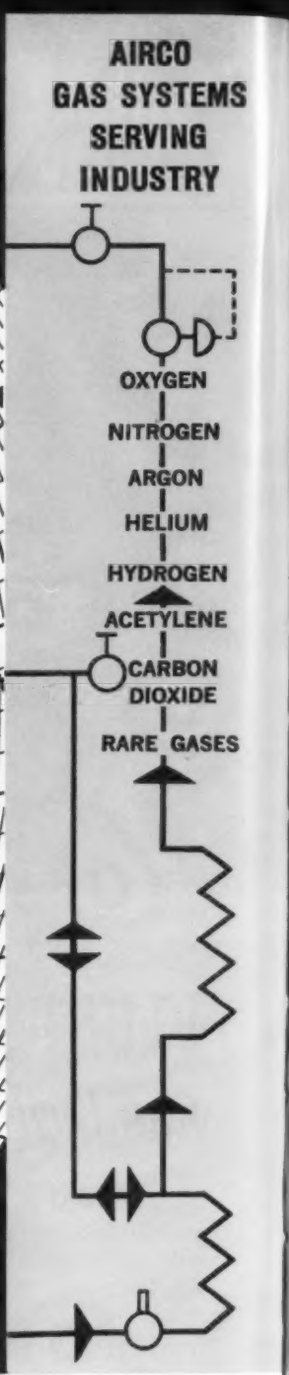

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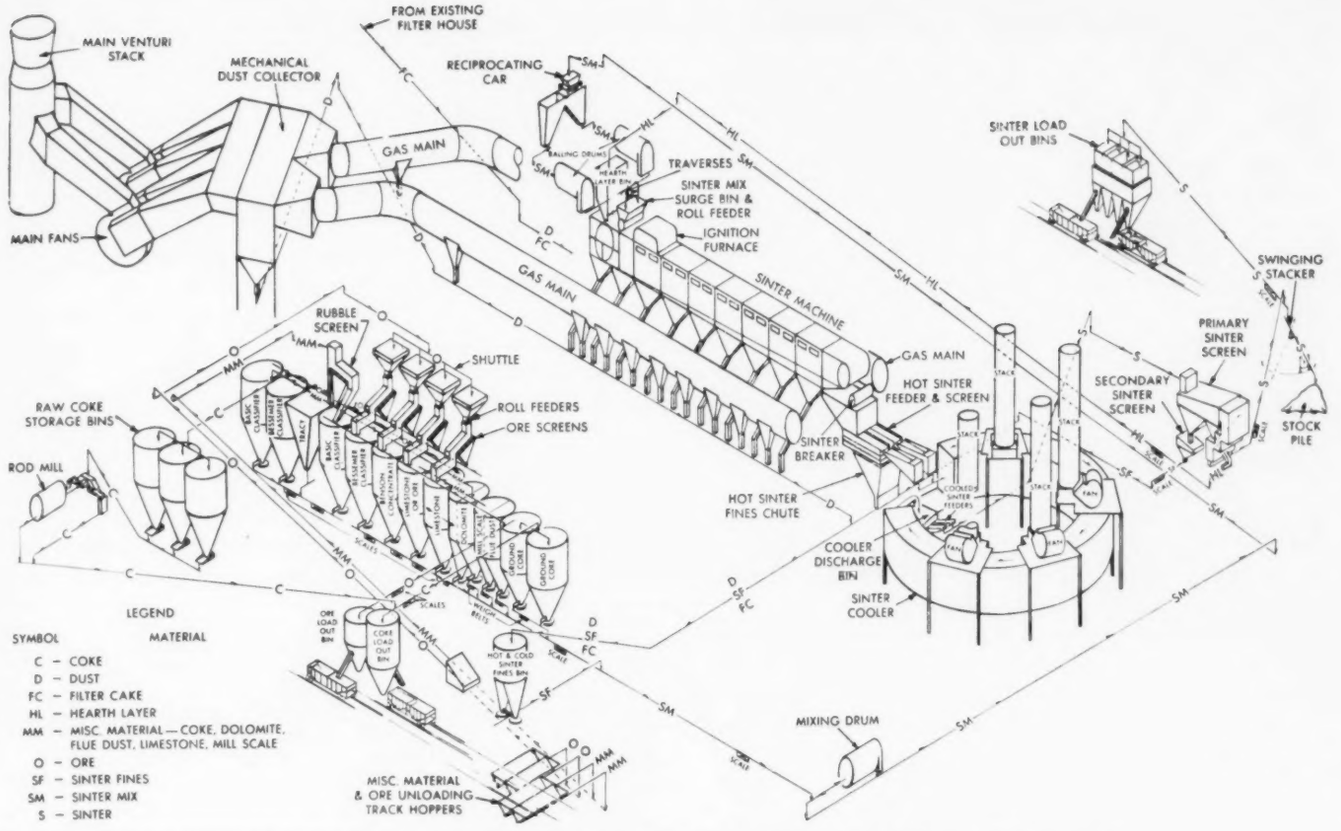

Figure 2 — Flow chart illustrates the raw material and product flow throughout the sintering operation.

eter cast steel wheels, riding on tapered bearings on 1045 steel stub shafts, which have been pressed into the pallet body and pinned by setscrews. Lubricated rollers on each shaft engage with the drive sprocket and tipping wheel, eliminating contact between pallets at either end of the machine.

On both top and bottom strands the pallet wheels run on steel rails. Fitted to the end of each pallet is a spring-loaded cartridge seal which contacts a lubricated seal bar on the wind box casting to form a tight grease seal between the pallet and the wind box.

The drive, intermediate and discharge end frames are of welded structural steel construction. The drive end only is bolted to the structural frame of the building; all intermediate and discharge end frames are mounted on rollers at the column bases to allow free expansion of the machine.

Spillage at the drive end of the machine is collected in vanes bolted to the torque tube and deposited on a transverse Dravo-Schenck vibro feeder, which discharges into a chute leading to the spill hoppers under the machine. At the discharge end of the machine spillage is collected in a hopper and discharged into chutes which feed into the hot sinter feeder.

Of welded structural steel, the 14 divided wind boxes are connected alternately from the top frame to a 12 ft-6-in. diameter gas main on either side of the strand. The connections are equipped with winch-operated butterfly valves and expansion joints.

The gas mains exhaust into banks of multi-tube type mechanical dust collectors. Two feet in diameter, the tubes are of centrifugally cast alloy steel. Space also has been provided for future installation of electrostatic precipitators.

Induced draft is provided by twin fans, each rated at 350,000 cfm at 350 F and producing a vacuum of 35-in. water gage at the fan inlet. The 12 ft-5¾-in. diameter rotors are constructed on a 13-in. hollow-bored forged shaft and mounted in 8-in. self-alining, pressure lubricated sleeve bearings.

Driving the fans at 720 rpm are 3500-hp synchronous, totally enclosed water-cooled motors with internal air-to-water heat exchangers suitable for outdoor installation. Dampers are located in the inlet breeching of the fans, and the fans exhaust to a gunite-lined stack 18 ft in diam and 140 ft high, with a Venturi section 40 ft from the top.

A crossover damper between the two gas mains permits the machine to be run at limited capacity while only one fan is operating.

Sinter cake from the machine is discharged onto a crash deck for reduction by a Dravo-Lurgi sinter breaker to a nominal 6-in. size. The breaker consists of a hexagonal shaft on which are mounted renewable hubs and breaker arms, which break the sinter cake through grizzly bars spaced to produce the desired size.

Burned out of 4-in. mild steel plate and hard-surfaced at the critical cutting nose, the breaker arms are designed to be expendable and inexpensive and can be replaced with a minimum of effort.

The breaker arm shaft is driven at approximately 4½ rpm through a bull gear driven by a reducer, powered through V-belts by a 75-hp, 1150-rpm a-c motor. A shear pin in the flexible coupling connecting the low speed shaft of the reducer and the pinion shaft protects against possible jamming or overload. Connected to the pinion shaft is a zero speed switch interlocked to the plant controls.

Enclosing the entire discharge end

and the breaker assembly is a hood from which air is exhausted to the dust collection system. Beams on which a hoist can be connected are mounted in the hood over the breaker assembly and crash deck to facilitate handling of renewable wear plates, breaker arms and grizzly bars.

Gross product of the sinter machine is conveyed from the breaker and screened by two parallel Dravo-Schenck vibrating feeder screens and two vibrating feeders. Each feeder screen is 32 ft-8-in. long and 6 ft-6 in. wide with a screening deck area of 112 sq ft. Approximately 15 per cent of the deck area is perforated with $\frac{3}{8}$ x 1-in. staggered herringbone openings.

Hot screened fines are chuted to a hooded pan conveyor leading to the hot and cold fines storage bin. Sinter product is conveyed to the cooler by the 6-ft wide, 17 ft-7-in. vibrating feeders.

The cooler, which has a mean diameter of 110 ft, has a supporting structure of welded structural steel, with the driving force and guiding reactions taken by the circumferential ring structure.

Alinement is maintained by supporting inner and outer rail circles on the base structure. Lateral forces are virtually eliminated, dependence upon the rails for guiding the trays occurring predominantly in the dumping position, where a configuration of the rail drops the trailing edge of the trays and returns them to the running position at the load point.

The rotating frame consists of two wide-flange beams, bent accurately to form inner and outer circular frames held concentric by radial tubular members which serve to locate the trays and provide the pivot for the leading edges of the trays when dumping. Attached to the wide flange is an accurately machined segmental driving ring flange, which provides a uniform surface for the friction drive wheels.

Support for the rotating frame is through the wheels of the trays, except in the dumping zone where a roller mounted on the supporting structure carries the weight of the trays hanging from the radial pivot members of the rotating frame.

Three horizontal guide rollers provide reaction to the driving force imposed on the rotating frame by contact with the machined edge of the frame flange, thus relieving the support roller and tray wheels of most lateral forces.

The cooler is driven by a 15-hp, 230-volt, 575/1750-rpm motor V-belted to a reducer, which is connected directly to a final drive pinion and gear. A smooth-rimmed friction wheel on the output shaft of the drive assembly contacts the bottom surface of the rotating frame driving flange. The entire drive assembly is mounted on a unit frame base supported on a horizontal axis.

Driving friction force stems from an adjustable spring-loaded backup wheel, supported from the drive assembly base which bears against the top surface of the rotating frame driving flange directly opposite the driving wheel. Drive speed ranges from 6 to 18 fpm.

The open-ended cooler trays, which overlap to form a continuous circular conveyor, consist of a heavy angle frame and reinforced side plates with a contour-formed segmental seal flange.

Leading edge of each tray nests into the trailing edge of the preceding tray, permitting the lowering of the trailing edge to effect dumping. Two pivot blocks mounted on the leading edge locate each tray relative to the rotating frame and to each other. A louvre bottom in each tray distributes cooling air while supporting the sinter bed. Fines small enough to pass through the louvres are retained by a wire mesh screen.

Tray wheels of spin-hardened cast steel run on an axle located near the tray's trailing edge. The continuous walkway around the cooler at tray level provides access for lubricating the wheel bearings.

A suction hood and air locks cover all of the tray circle except the dumping and loading zones. The hood is designed to effect a continuous air seal at the segmental flange at the top of tray sides, and the large volume enclosed distributes fan suction evenly over the cooling area. Access openings are provided for inspection of the trays.

The hood is constructed of angle reinforced plate, with expansion joints. At each end are finger-type air locks with spring-loaded shock absorbers which maintain a minimum clear opening at the entrance and exit of the hood.

Each centrifugal-type fan, driven by a 300-hp motor, draws cooling air through a specific sector of the cooling bed; diaphragms in the hood separate one suction area from another, assuring maximum air flow through the sinter bed. For each of the four fans there is an individual stack with a hopper bottom for collecting settled dust.

The cooler trays are uniformly loaded from the vibro-feeders through two loading chutes to reduce deterioration of the sinter.

The trays dump into a discharge hopper under which are located two feeders, so arranged that one operates mainly on overflow while the other has a relatively uniform discharge. This is done to limit surge on the product belt. The discharge hopper is of stone box design to limit wear and sinter degradation.

From the cooler, the cooled sinter is conveyed to the sinter screening station and discharged onto a Dravo-Schenck primary screen. This unit, 9-ft wide and 21 ft-6-in. long, contains a 12-ft section of $\frac{3}{8}$ x 1-in. slotted openings and a 6-ft section of $\frac{3}{4}$-in. staggered circular openings.

All plus $\frac{3}{4}$-in. sinter is fed to product, while a separate bin collects minus $\frac{3}{4}$-in. x plus $\frac{3}{8}$-in. sinter for hearth layer. This bin will overflow to product after hearth layer requirements are satisfied. All minus $\frac{3}{8}$-in. fines are returned to a storage bin by a hooded pan conveyor.

A secondary screen, 4-ft wide and 10 ft-6-in. long, has been installed for rescreening minus $\frac{3}{8}$-in. fines to obtain plus $\frac{3}{16}$-in. fines for product when desired.

Final sinter product is conveyed either to a loadout station or to an emergency 70-ft long swinging stacker for stocking directly to the ore yard. Sinter at the loadout station can be loaded to railroad hopper cars or ore yard transfer cars for transportation directly to blast furnace bins.

Dust control equipment is the most modern available. Dust from the main multi-tube dust collectors and gas main hoppers is handled on enclosed dust conveyor belts and a hooded pan conveyor. Separate dedusting systems have been provided for the discharge end of the sinter machine, the cooler area, and the sinter screen area. ▲

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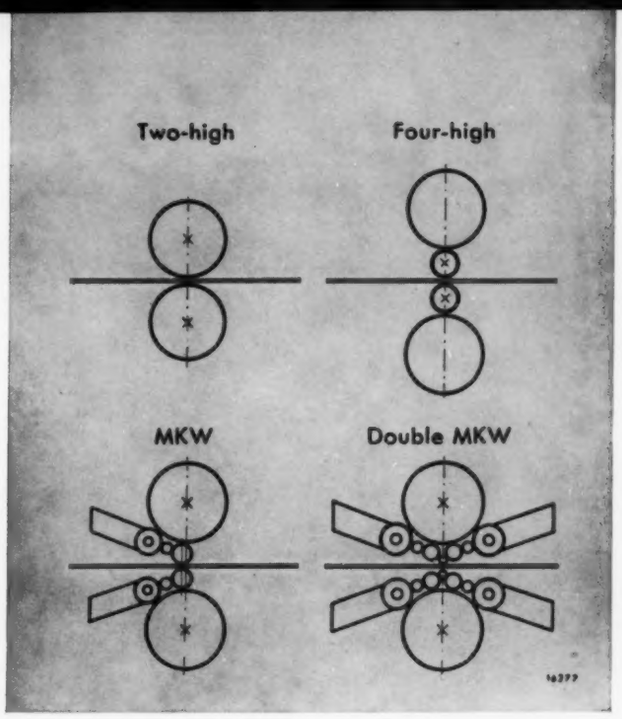
Multi-purpose rolling mill for "refractory" materials

Special alloys for the nuclear power and other industries have presented extraordinary problems. The new MKW mill (US and foreign patents) developed by SCHLOEMANN is ideally suited for rolling these refractory materials and is readily adaptable for conventional rolling work. Typical characteristics as included in the specifications of an MKW mill recently built for operation in the United States are as follows:

Hot and cold rolling – Initial thickness up to 2" Final thickness of strip – .006" standard; .001" min. Rolling force – in excess of 2200 tons at 24" strip width (twice the roll separating force required for rolling of conventional CrNi steels).

MKW 80 during workshop assembly. Above, the double MKW set-up is seen in run-out position; below, the view from the entry side shows the pay-off reel and coiler.



Four different roll set-ups for one mill:

Two-high set-up: 36" ∅ rolls

Four-high set-up: 16 1/2" ∅ driven work rolls

MKW set-up: 36" ∅ driven back-up rolls, 5" to 5 1/2" ∅ work rolls

Double MKW set-up: 36" ∅ driven back-up rolls, 2" to 2 1/4" ∅ work rolls

Wide working range

The mill is equipped with four different roll set-ups and is thus provided with an extremely wide working range. Since the new super high-grade but difficult-to-work materials are currently required in comparatively small quantities only, the use of one MKW mill with four different roll set-ups offers practical and economical advantages.

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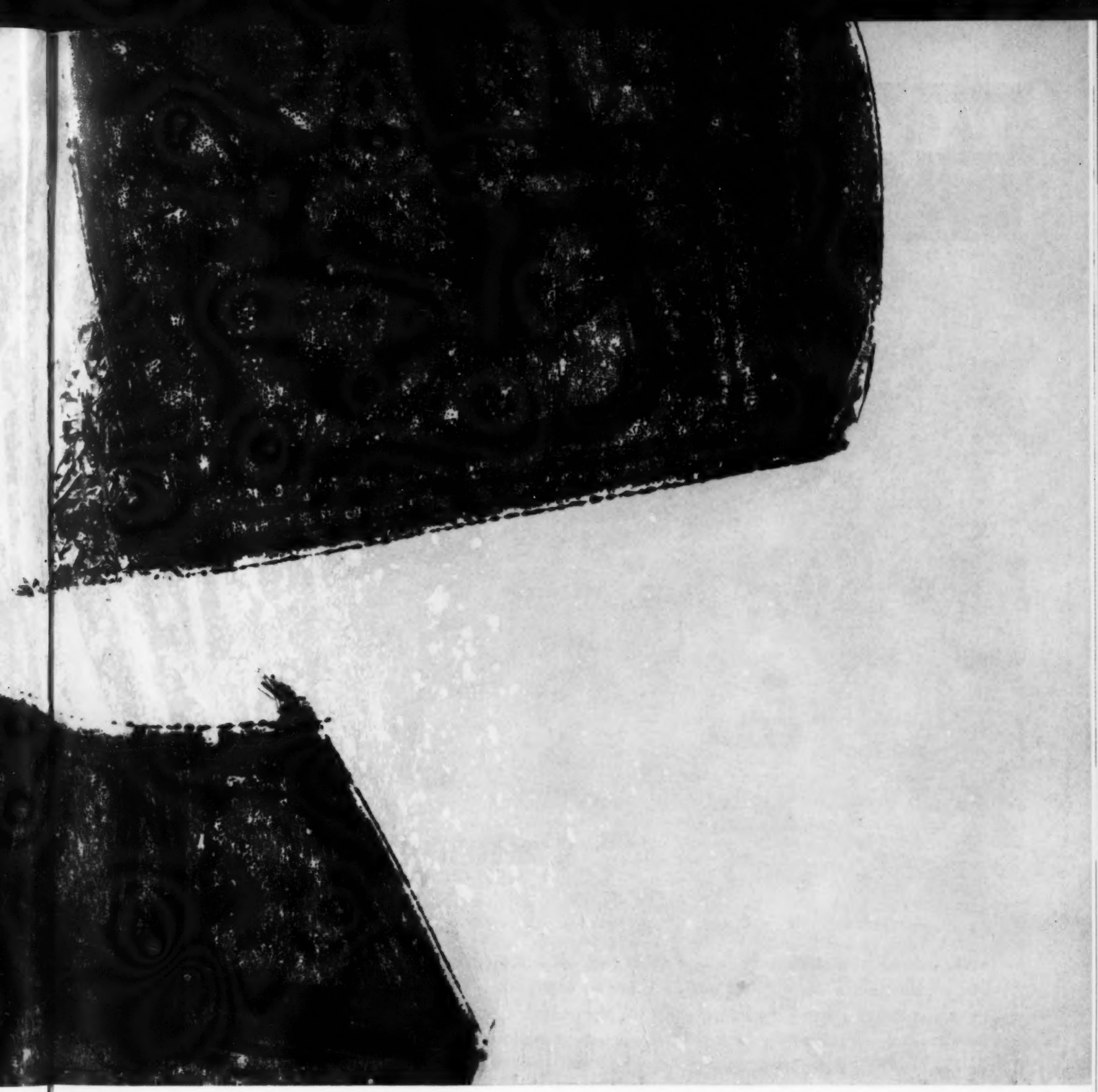

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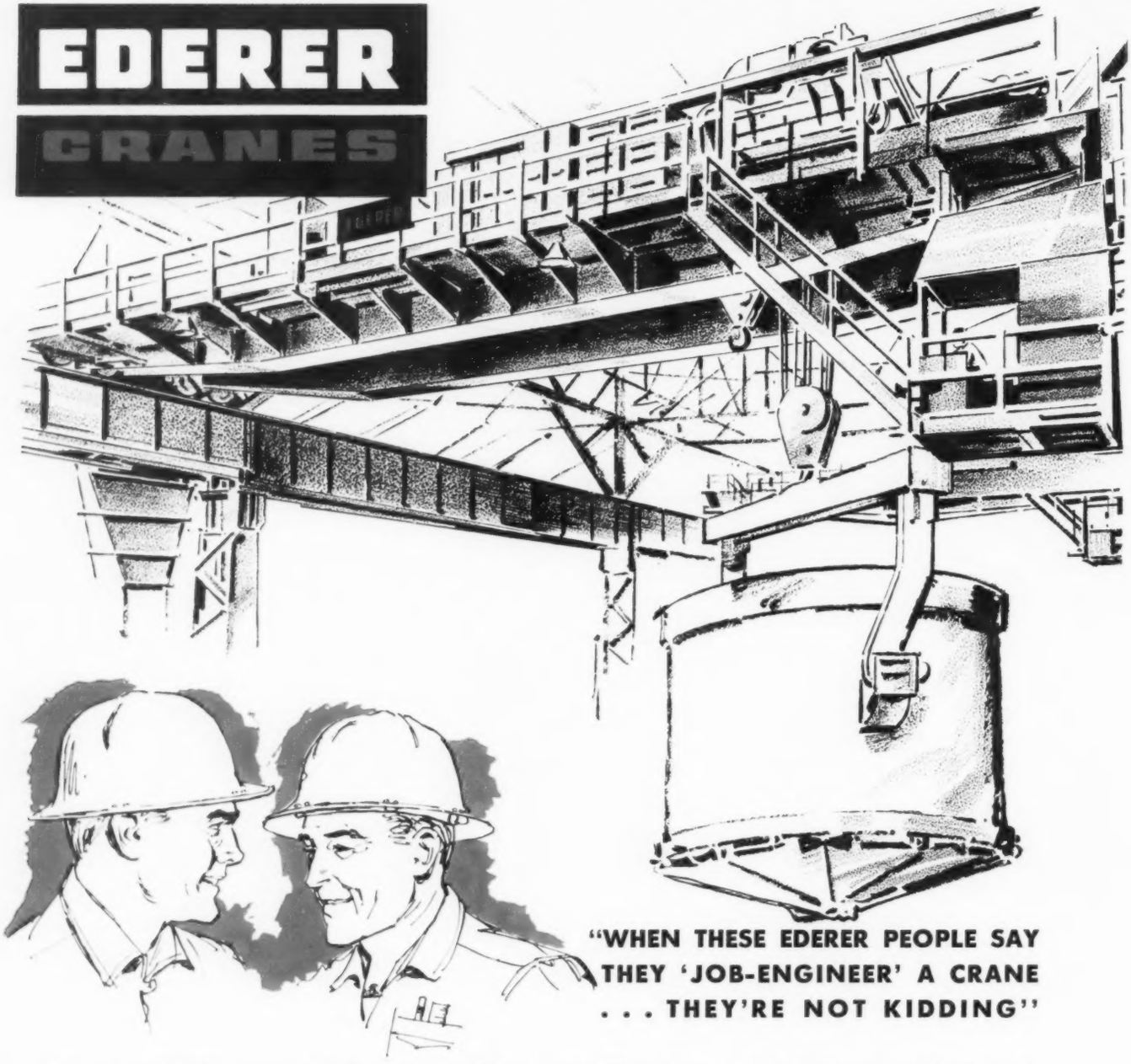

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Acme Steel Puts New Hot Strip Mill into Operation

ONE of the most modern hot strip steel rolling mills in the country has gone into operation at Acme Steel Co.'s plant in suburban Riverdale, south of Chicago.

The new semi-continuous mill, to be known as No. 4 mill, converts steel slabs into continuous coils, weighing up to 500 lb per in. of width with an improved surface as a result of greater descaling water pressure available on the new mill.

The No. 4 mill is part of the company's $46,000,000 integration and modernization program which included the installation, in 1959, of a $35,000,000 melt shop containing a new steelmaking process which combines continuous hot blast cupolas with top blown oxygen converters.

The old mill was removed and the new mill installed within a record period of 30 days, on the exact site of its predecessor which had been in operation since 1926. A 100-ft extension to the existing mill building was added to house the new slab heating furnace and the overall length of the new mill is 1040 ft. To reduce the time required for installation of the new facilities, precast concrete foundations were produced off the site in advance of the excavation period, permitting them to set and cure before being put into place.

After breaking in and synchronizing the various components of the mill and training the men in the operation of the new facilities it will be possible to double the production of the former unit. Slabs will be rolled into large continuous coils in widths of 8 to 22¼ in. and thicknesses from 0.050 to 0.375 in. Some coils weigh as much as 10,000 lb. In the narrower widths, they will average approximately 50 in. in diameter and in lighter gages, will be a continuous strip of steel one half mile long.

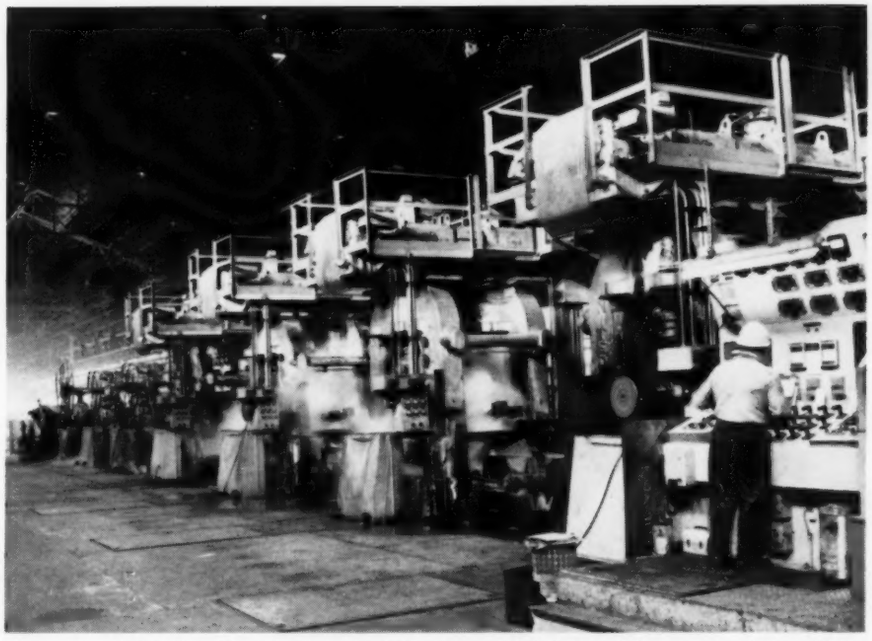


Figure 1 — The finishing train consists of two 2-high breakdown stands and four 4-high finishing stands which reduce the strip thickness to a final gage of 0.050 to 0.375 in. at a rate 90 tons per hr.

Auxiliary equipment of the mill includes two new modern shear lines, a new normalizing furnace and improved pickling and recoiling facilities.

Future plans contemplate widening the mill to produce coils of greater widths. To accomplish this will require only minor alterations in the existing mill equipment. These plans also include the addition of a second slab heating furnace and an additional coiler.

Presently steel slabs 30-ft long and 4½-in. thick are heated to approximately 2200 F in the furnace which delivers 125 tons of slabs per hr. These slabs, 9 in. to 22¼-in. wide, are reduced in a reversing roughing mill from a thickness of 4½ to ¾ in.

This operation, requiring five passes through the reversing mill, is completed in 65 sec. The reversing rougher is one of the first finishing mill installations which incorporates an electronic unit that automatically controls the starting, rolling, decelerating, stopping and reversing of the mill and the tables in proper sequence on each pass which the bar makes through the stand.

After leaving the reversing mill, the hot strip proceeds to the continuous finishing train before being coiled on a new downcoiler and automatically transferred to a coil cooling conveyor.

The hot rolled coils may be shipped direct to customers. Or according to their requirements they may be transferred to other departments for further processing such as cutting to length, pickling, cold rolling or electrogalvanizing. ▲

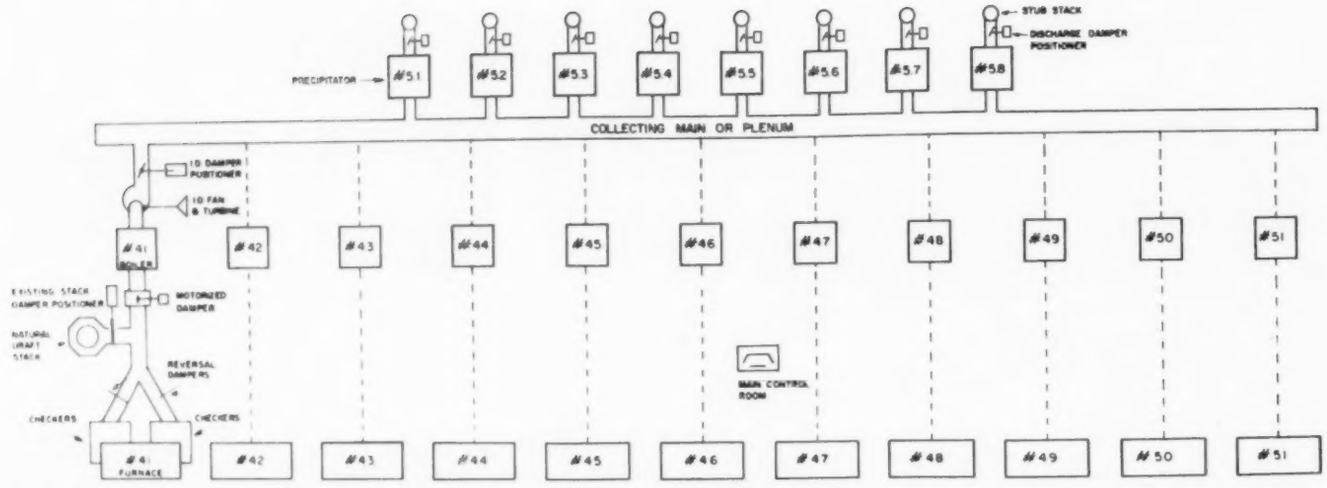


Figure 1 — System throughout the ¼-mile long open hearth shop is operated from a central 40-ft control room. The automation procedure is expected to reduce operating costs while providing effective control of open hearth dust.

Smoke Control at J&L to Provide Operating Benefits

MAGNETIC control and analog information systems designed by Hagan Chemicals & Controls, Inc., are the keystones of a new open hearth air pollution control installation at the Pittsburgh works of Jones & Laughlin Steel Corp.

Electrostatic precipitators manufactured by Koppers Co., Inc., are being installed on open hearth furnaces. Hagan magnetic controls and an alarm indicating monitor (AIM) will play important roles in the over-all automation of the eight precipitators and the 11 waste heat boilers.

The Hagan AIM will provide alarm and indication if any of 220 critical flows, temperatures, pressures or levels get out-of-limits. Thus, the operator in the central control house has continuous, automatic supervision of the system. A graphic control panel will present clear operating information at all times, and further centralize the operation of the coordinated systems.

Steam will be produced in the waste heat boilers at a temperature and pressure that will permit its utilization in the power house and blast furnace blower house located on the other side of the Monongahela river from the open hearth shop. Lower pressure steam, presently available for fuel atomization in the open hearth furnaces, will drive the waste heat boiler feed pumps and induced draft fans. The systems will control boiler drum levels, flue gas system draft, precipitator paralleling, feedwater pressure and feedpump recirculation.

One waste heat boiler and precipitator combination was installed and put into operation on No. 41 furnace in 1959 to gain experience. Operation of this facility revealed a number of refinements which were incorporated in the complete layout.

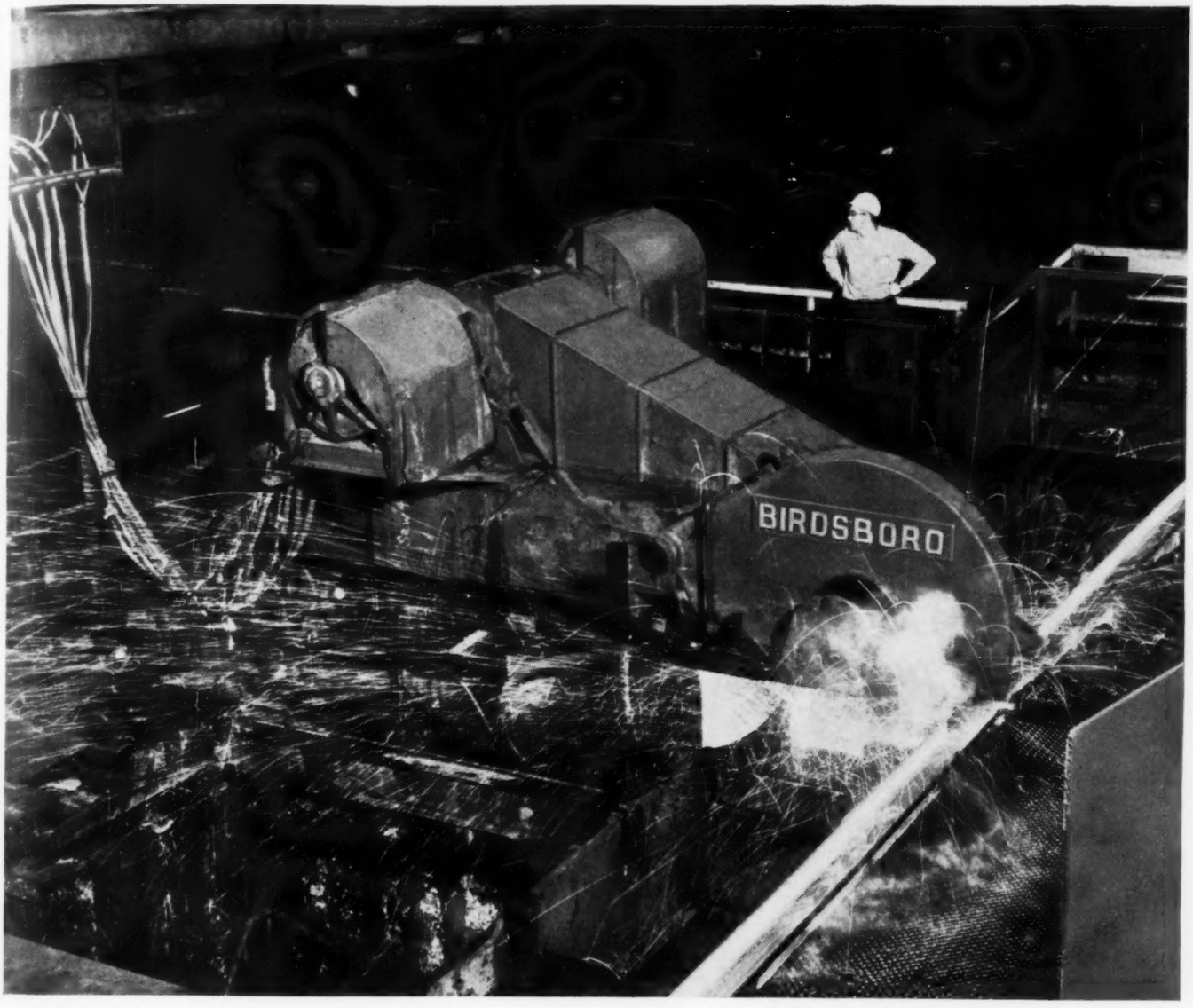
The new waste heat boiler and precipitator control is tied into the existing furnace control and electrically interlocked to provide safety of operation. Provision is made to direct hot flue gases from the open hearth over to existing natural draft stacks in the event of operating difficulties, which will prevent interference with steel production while the operating difficulties are being located.

Provision is also made for sequential restoration of the boilers after outages. Gradual warm-up of the boiler and final transfer of draft control from the stack to the waste heat boiler and precipitators is accomplished in steps.

A large header collects the gases from the open hearth furnaces and discharges into the eight precipitators. Pressure in this header is controlled at a constant value by varying the rate of flow to the eight precipitators. The signal from the pressure controller goes to eight collector flow controllers, acting as a common set point for all eight. These flow controllers in turn operate dampers on the discharge of each precipitator, which parallels the flow equally between all eight or any other operating number of precipitators.

The "centralized control" concept, practically applied on this job, is another example of the operation of all the control and measurement apparatus on a process from a central location. The growing acceptance of industrial centralized control stems from a number of considerations, including: ease of control from a central location; greater control accuracy from centrally available measurements; reduction of supervisory requirements; increased safety with all measurement and control indications at the fingertips; and faster plant-wide operation by the operators. ▲

It takes only 420 seconds to change blades on this **BIRDSBORO** Hot Saw



● Dynamic braking brings the whirring blade of this Birdsboro hot saw to a complete stop in 35 seconds. Removal and replacement take 385 more. Then it's back in operation again . . . with only a fleeting production interruption for its owner, Inland Steel.

Inland has two of these 68" Birdsboro hot saws. They are designed to cut rounds and squares, as well as wide flange beams—in lengths from 10′ to 75′, at temperatures from 1300°F to 1800°F.

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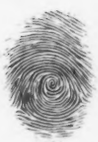

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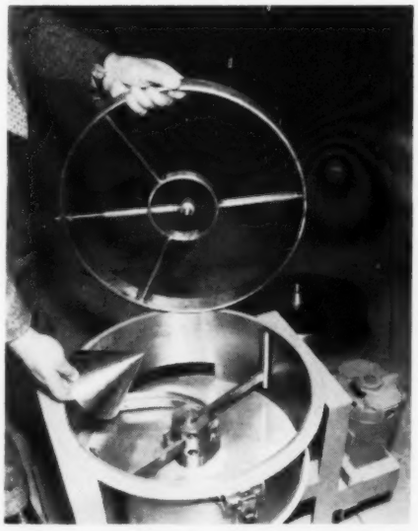
Continuous-Flow Conditioner

Provides Dust-Free Handling of Bulk Materials

A NEW bulk-material conditioner has been developed by The Johnson–March Corp., Philadelphia, Pa., that permits dust-free handling of powdery, finely-divided materials. For the first time, the material conditioner, called Verticone, makes bagging operations, loading and unloading from bins, silos, ships, trucks or rail cars and especially dust collector bins dust-free.

Of particular importance to the metal trade is the ability of the Verticone to handle blast furnace flue dust and sinter fines, converter and electric furnace dust from collection equipment and make it dust-free and manageable. Elaborate systems have been installed in many plants to trap as much as 100 to 120 tons of hot dust per day, but until the development of the Verticone, it has been difficult to handle the dust after it was collected. Various systems have been tried such as filling rail cars and letting the material sit until it was cool enough to handle, or mixing the dust with large amounts of water to make a slurry and pumping the mixture. Both approaches have substantial drawbacks.

Figure 1 — All size Verticones are designed for easy cleaning. The top housing is latched to the main body shell. Main body shell, blades and rotary discharge table are readily accessible by lifting out the cone and cone holder. In units with sanitary construction, all parts are removable.



The new Johnson–March Verticone suppresses dust by adding a precisely controlled amount of moisture into the finely-divided material. The key to effective conditioning is controlled wetting of all the surfaces of each particle with an extremely powerful surface active compound, called Compound MR. Controlled wetting by the Verticone adds as little as one per cent of moisture. Wetting may be adjusted to apply any desired amount of moisture.

Rapid and effective conditioning can be obtained only by proper dispersion of the solid stream of material. This is accomplished by introducing the material onto a distributing cone at the top of the Verticone. The material falls over the cone and leaves the base of the cone in the form of a thin-walled, between $\frac{1}{4}$ and $\frac{3}{8}$-in. thick, hollow cylinder.

A spray jet inside the hollow cylinder of falling material applies the solution so that all the surfaces of the solids are properly conditioned and rendered dust-free. Internal scraper blades keep the sides of the Verticone clean at all times, preventing any build-up of materials. The treated materials drop onto a retention plate at the base of the Verticone where final and complete dispersion of the moisture takes place. A rotary table feeder discharges continuously to fit the flow of a materials handling system, or to rapidly load trucks or rail cars. The discharged material can be removed by conveyor, chute or other means as desired.

Such small amounts of moisture are added that it presents no interference with subsequent material handling equipment or processing methods. The necessity of reducing materials to a slurry is completely eliminated. Where incoming material temperature exceeds 250 F, rapid wetting is achieved by the generation of steam as plain water is applied through the spray jet. Under these circumstances, the use of the wetting agent is not recommended. However, the moisture content of the finished product is still precisely controlled by the Verticone application.

CONSTRUCTION

The Verticone is of heavy steel plate construction consisting of five main elements—top housing, cone, main body shell, cleaner blades and rotary discharge table and motor drive. Each element is constructed of metals best suited for its purpose. Stainless steel construction is available for sanitary applications. Wear areas such as the distribution cone and retention plates can be reinforced with removable wear plates. Cleaning

blades are easily replaceable. The complete unit can be located indoors or outside. Winterized equipment is available for year-round operation in areas where temperatures fall below freezing.

The Verticone is offered in three standard models to handle anywhere between 150 lb to 150 tons of material per hr.

AUXILIARY EQUIPMENT

The three basic operations of the Verticone are: (1) feeding, (2) conditioning and (3) material discharge. To properly coordinate these three functions, it is necessary to provide for some system of controls. Frequently, existing plant equipment will be adequate, but at other times auxiliary equipment may be necessary.

Bulk material flow must be controlled to within five per cent to maintain precise moisture addition. Small flow rates can be handled on an intermittent basis by providing temporary storage. The Verticone can be used as long as there is sufficient storage to provide a uniform material flow rate (±5 per cent) during the unloading period. Where existing equipment feeds within these limits, no additional feeder equipment is necessary. Where these conditions are not met, Johnson–March recommends the use of a vibrating screw feeder.

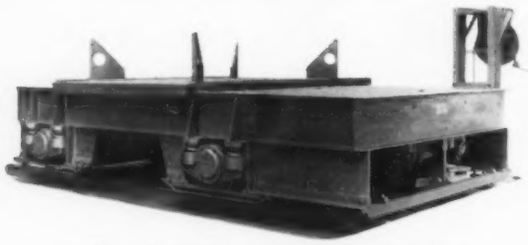
When it is necessary to wet the material with Compound MR, the compound must be proportioned with water at the ratio of one part compound to 750 parts water. Mixing is accomplished in a proportioning unit utilizing a bellows type pump that injects Compound MR into a mixing chamber simultaneously with the flow of water to the spray jet.

When it is not practical to discharge conditioned material directly from the Verticone to rail cars or trucks, it is often necessary to supply a conveyor. Two basic conveyors are available: a swivel conveyor that can be swung clear when not in use; or an inclined conveyor to be used when additional height is required for loading. Other conveyors can be designed in accordance with individual plant requirements.

COMPOUND MR

Compound MR is a special surface active agent which increases the wetting and penetrating power of applied moisture. Specially formulated to penetrate and wet industrial dusts, the compound is a nontoxic, odorless, colorless solution. In the diluted strength used in jet systems, it has no corrosive effects on machinery, conveyor belts, etc.

Most industrial dusts are at least partially water repellent. For this reason, chem-jet systems do not utilize plain water, but, rather, a chemical solution produced by the introduction of one part Compound MR into 1000 parts of water. The resultant solution has a surface tension less than one third that of untreated water. This solution has tremendous wetting, penetrating and spreading powers that are extremely effective in contacting, confining and suppressing dust. Dust can be controlled in many applications by the addition of as little as one half to one per cent moisture. ▲



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Variable Orifice Features Wet Scrubber

A NEW variable-orifice, wet scrubber has been developed by The Johnson-March Corp., Philadelphia, Pa. The new scrubber, called a Hydro-Volute scrubber with air volume control, develops high scrubbing efficiencies on a wide range of fumes, dust and odor problems despite substantial variation of air or gas flow. Scrubbing efficiency of fixed orifice scrubbers drops off substantially as flow is decreased.

Both manual and automatic air volume controls are available to assure constant efficiency over wide variations in air flow. In the automatic models, changes in air flow are detected by a differential pressure switch which actuates the modulating control. The Johnson–March variable orifice scrubber will compensate for changes in air flow of as much as 35 per cent from original design capacity.

High efficiencies (pilot unit tests have shown efficiencies up to 99 per cent on materials as fine as fly ash) are obtained from the excellent scrubbing achieved by the counter flow of gas and water, producing a vortex in a series of chambers. Each chamber is shaped to produce a swirling action within the chamber so the gas is scrubbed with water and wetted dust particles are centrifuged out of the gas stream.

The scrubber requires very little space. A 1000-cfm unit is the size of an office file cabinet including the moisture extractor on the top. A 10,000-cfm scrubber requires only 25 sq ft of floor space. Compactness does not hamper dust handling ability. High scrubbing efficiencies have been experienced on dust loadings of 15 to 20 grains per cu ft. (Effluent from an asphalt plant containing seven grains per cu ft produces three tons of dust per 8-hr day.)

Hydro-Volute scrubbers are available in a range of capacities of from 1000 to 60,000 cfm. Constant or intermittent removal of sludge can be accomplished either manually, hydraulically or mechanically depending on the need and application. Unit back pressure is low—four and a half inches of water—so that existing fans and blowers can generally handle the additional load.

All units from 1000 to 10,000 cfm include a reservoir, liquid level control, moisture extractor and one or more water-tight access doors as standard equipment. Units above 12,000 cfm are similarly equipped except that no reservoir is required when a settling pond is used. Heavy dust loading and high temperatures necessitate a settling pond. Inlet location is optional. ▲

Figure 1 — The new variable-orifice (right), Hydro-Volute scrubber develops high scrubbing efficiencies despite substantial variation of air or gas flow. The scrubber is not limited by either high moisture or temperature conditions of effluent gas and can be used virtually anywhere in industry where a dust, fume or odor problem exists. A fixed-orifice, 2-stage scrubber is also shown (left).

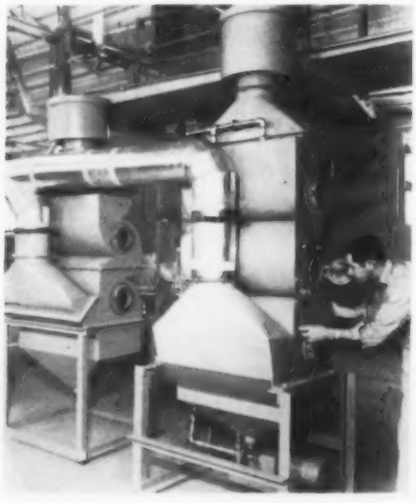
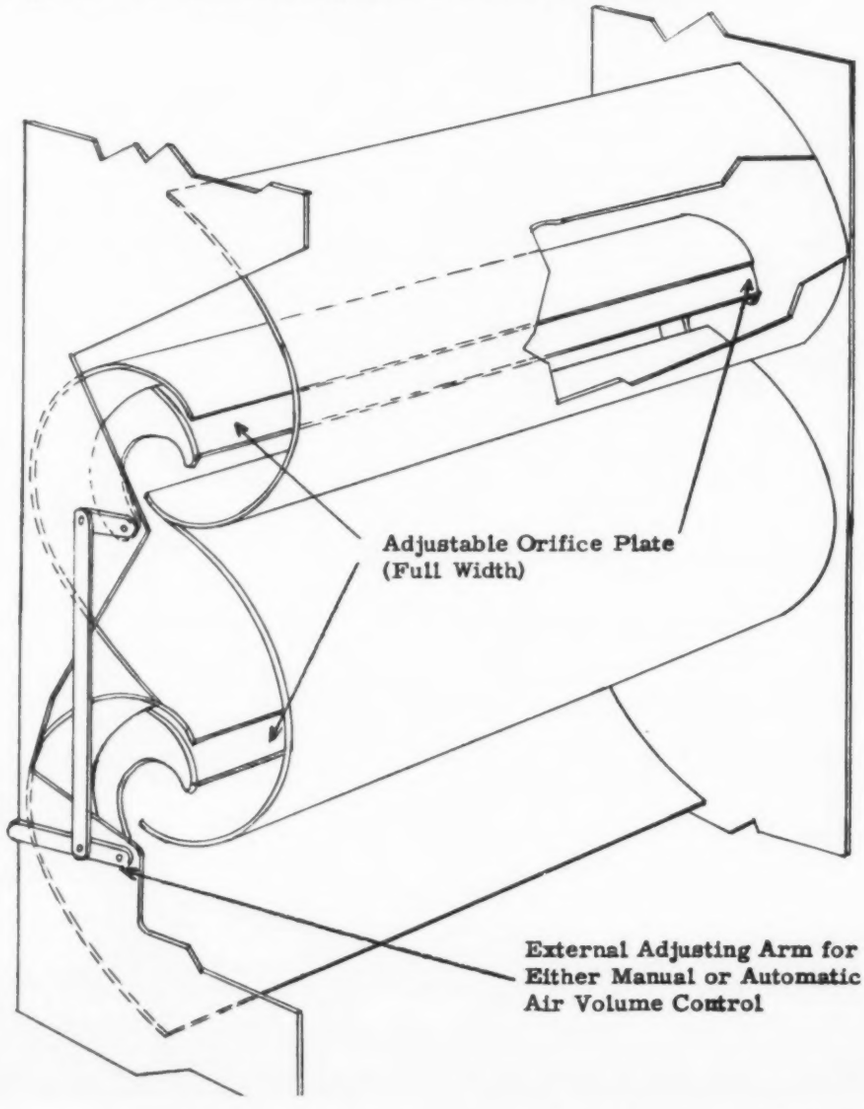


Figure 2 — Volume control may be either manual or automatic.



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The entire operation from charge to discharge is directed from an air conditioned booth which utilizes television monitoring and radio intercommunication from booth to floor.

The rolls of each unit have separate drives—maximum line speed is 200 fpm, variable to a low of 0.3 fpm in the tempering furnace.

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Large vs Small Blast Furnace Bells

by T. AN. TESCH, Chairman of the Board of Directors,
T. An. Tesch A-B, Engineers and Contractors, Stockholm, Sweden

THE importance of increasing the life of the furnace bell is certainly clear for every blast furnace operator. It is evident that furnace bells of such large dimensions (18 ft-0 in.) as the one described by Mr. Fluck in the September, 1960, *Iron and Steel Engineer* involve problems in manufacturing and handling. The question may therefore be raised as to why the modern blast furnace engineers is inclined to follow the practice applied for smaller furnace units of designing the main bell to fit the throat of the furnace shaft instead of looking for the more practical solution of using a bell of more reasonable dimensions.

Adopting a relatively small main bell will naturally require some distributing equipment below the bell, and the reason for the above mentioned conservatism may be that the high temperature which occasionally reigns at the throat of the classic blast furnace may jeopardize the life of any mechanical device installed.

Therefore, there are some pertinent factors to be considered:

1. Why do high temperatures often occur at the throat of the shaft?
2. Why feed a blast furnace with one large diameter bell which causes the charge to segregate during its fall depositing the larger lumps toward the walls and the finer toward the crater of the center of the shaft?
3. Why should the active furnace volume be hardly 50 per cent of the total?

All these evils may be overcome by giving proper attention to a correct and rational distribution of the charge below the bell giving an even resistance to the ascending gases in the shaft which causes the isotherms, Figure 1, to approach parallel horizontal lines and even temperatures in the different horizontal zones of the furnace shaft.

By using the system of selective charging, which of course is arranged to work automatically, the operator has in his hands means to stifle the flow of the gases near the furnace walls, where the resistance is lower, forcing them toward the center in order to produce an equilibrium of the flow. This produces a lower temperature at the top even with reduced height of the shaft.

For selective charging two bells are used, the main bell and a spreader bell inside, as well as a fixed spreader suspended from the hopper.

The diameter of the bells does not

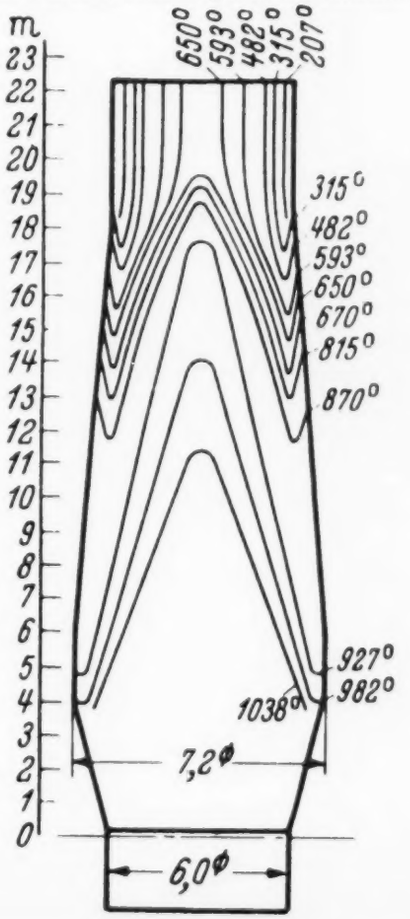

Figure 1 — The Kinney diagram illustrates that the same temperature, stated here in degrees C, does not exist across any plane of the furnace parallel to the hearth. The tuyere level is the base line for height measurement.

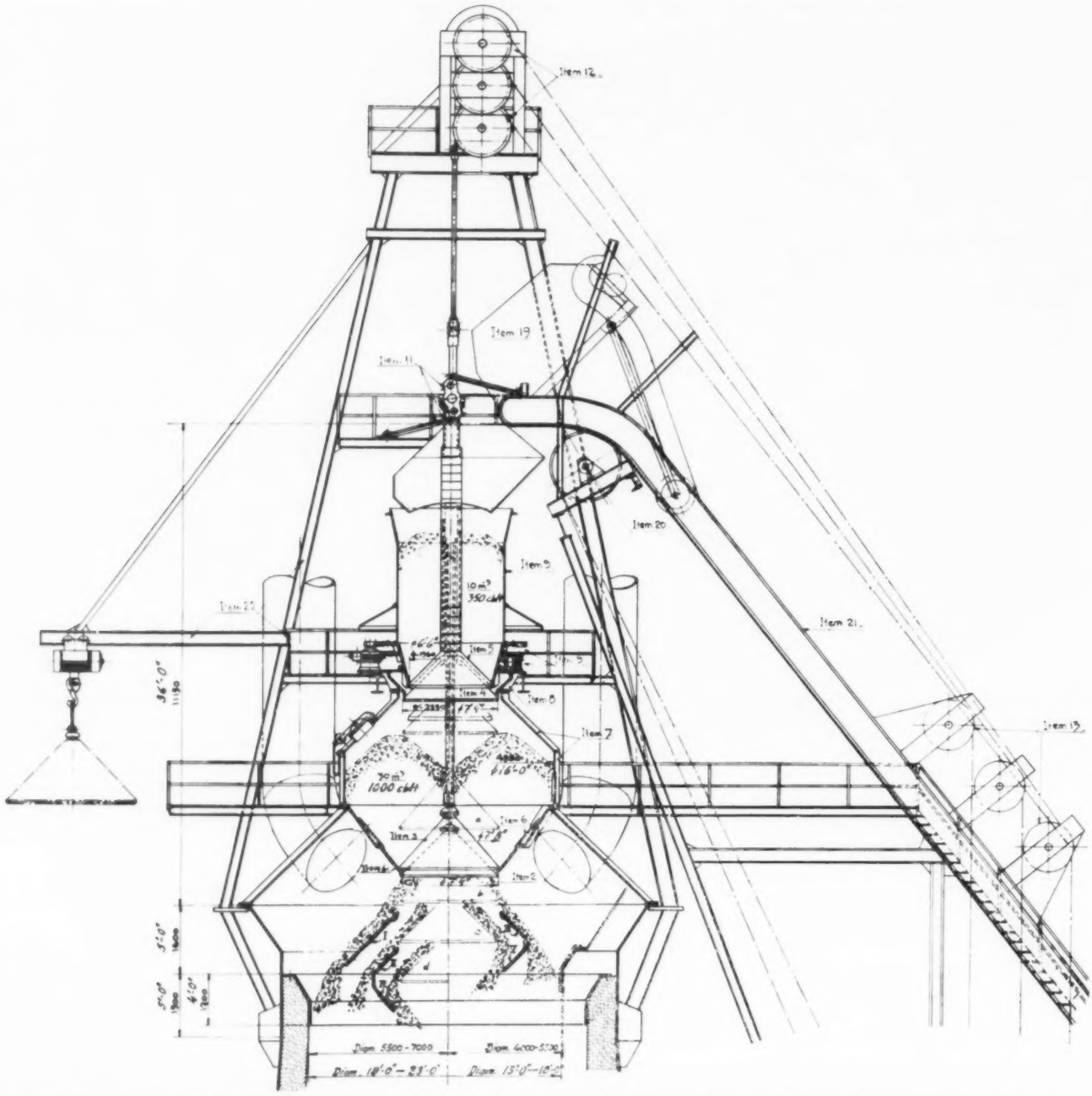

Figure 2 — Proper distribution of the burden using a bell smaller in diameter than the furnace throat, requires spreading equipment below the bell, equipment which will not segregate the burden into groupings of large and small lumps.

exceed 10 ft-0 in. even for the largest blast furnace, and the general arrangement of the top may be seen from Figure 2 for high blast pressure at the top. Design for low pressure furnace is quite similar.

Should, however, the blast furnace engineer insist on maintaining his large bell, why not then arrange it with an apron forming the extension of the bell made of wear resistant steel and replaceable? ▲

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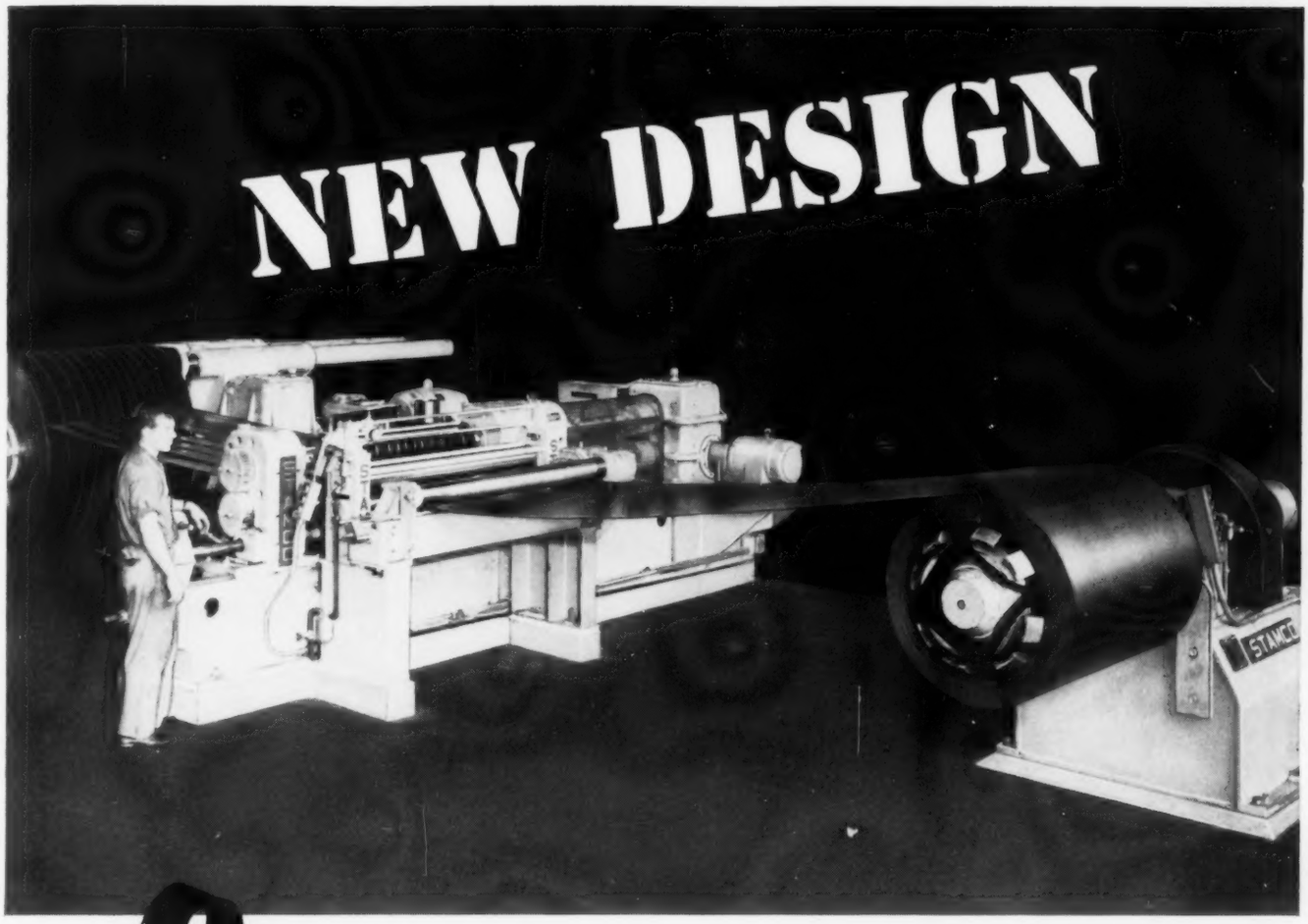

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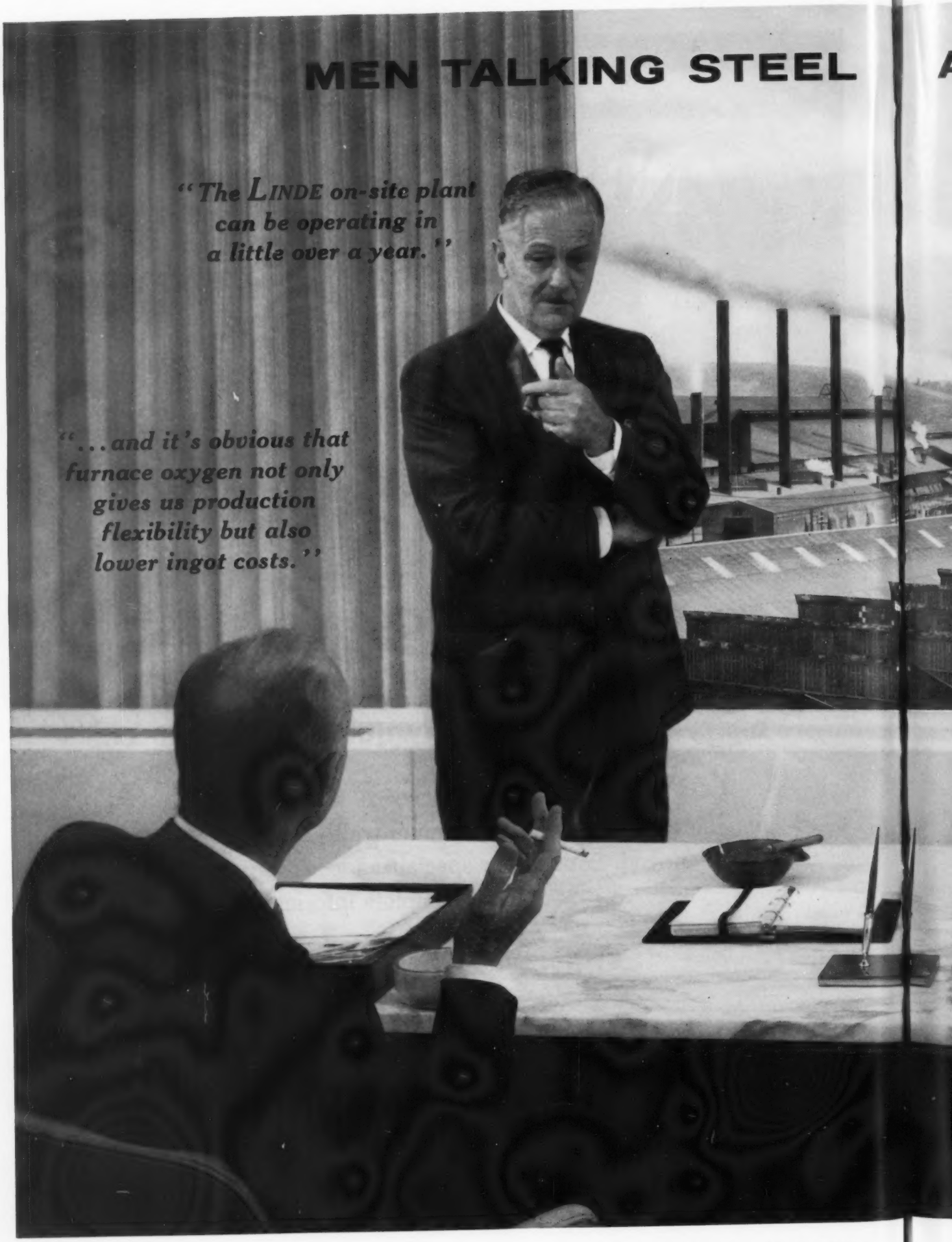
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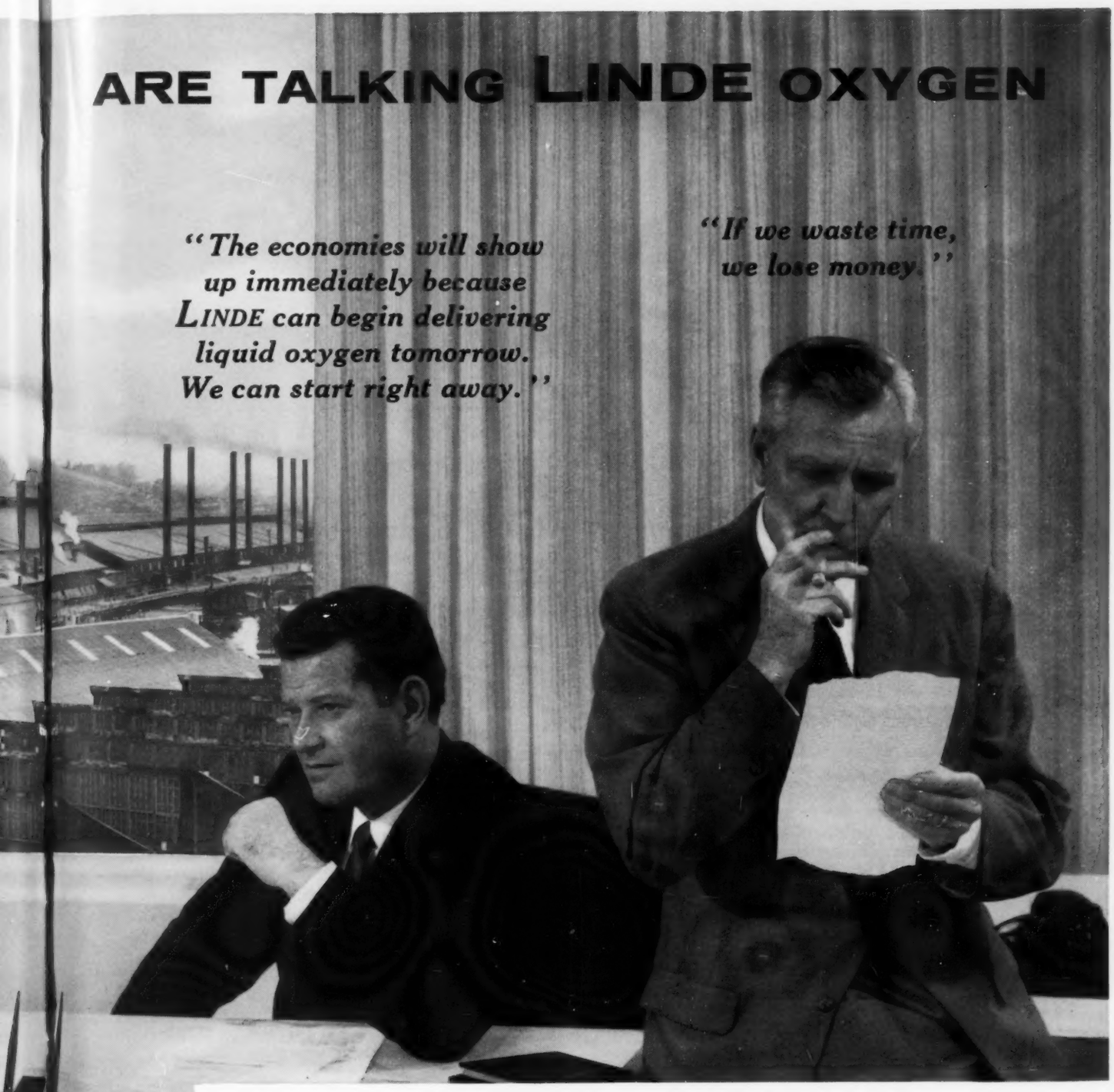
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Date-line Diary...

February 2

Δ The Bureau of Statistics reports that Canadian steel production for the week ending January 28, 1961 was 96,254 tons down from 105,456 tons the previous week and below the 127,205 tons in the same week of 1959.

Δ Union Carbide Metals Co. reduced price for all grades of regular and nitrogen bearing low-carbon ferrochrome 2¢ per lb of contained chromium in average bulk carload lots.

Δ Auto assemblies in January, 1961, totaled 414,498 cars compared with 542,057 in January, 1960.

February 3

Δ The Bureau of Census reports that shipments of iron and steel castings in November, 1960, totaled 998,264 tons compared with 1,071,314 tons in October, 1960, and 998,461 tons in November, 1959.

February 4

Δ The AISI reported that steel production for the week ending February 4, 1961, totaled 1,492,000 net tons (52.2 per cent of capacity), compared with 1,466,000 tons one week ago (50.9 per cent of capacity), and 2,683,000 tons one year ago. Index of production for the week was 80.1.

February 6

Δ The Bureau of Mines reported that production of Pennsylvania anthracite in January, 1961, totaled 1,825,000 tons compared with 1,724,000 tons in December, 1960, and 1,634,000 tons in January, 1960.

Δ American Iron Ore Assn. and AISI joint report shows receipts of iron ore in the United States for December, 1960, amounted to 2,659,674 gross tons, compared with 10,942,940 tons in December, 1959. Recepits of iron ore in the U. S. in 1960 totaled 112,756,432 tons, compared with 91,525,345 tons in 1959. Blast furnaces in operation on December 31, 1960, totaled 125 of the existing 258. On December 31, 1959, 224 blast furnaces were in operation.

February 7

Δ Dealers delivered 130,500 U. S.-made cars in the period January 21 to 31, 1961, compared with 133,650 sold in the mid-third of January, 1961, and 173,000 cars sold in the same period of January, 1960.

Δ The AISI reported that shipments of finished mill products in 1960 totaled 71,149,218 net tons, compared with 69,377,067 tons in 1959. Shipments in December, 1961, totaled 4,116,047 tons compared with 4,516,020 tons shipped in November, 1960.

February 8

Δ The present administration estimates a deficit of $2,000,000,000 for fiscal 1962 instead of a surplus of $1,500,000,000 projected by former President Eisenhower.

Δ The Bureau of Mines reports that production of pig iron in October, 1960, totaled 4,510,819 tons.

February 10

Δ The Labor Dept. reported that unemployment on January 15, 1961, totaled 5,400,000, up 850,000 from the mid-December, 1960 figure.

February 11

Δ The AISI reported that steel production for the week ending February 11, 1961, totaled 1,524,000 net tons (53.5 per cent of capacity), compared with 1,492,000 tons one week ago (52.2 per cent of capacity), and 2,687,000 tons one year ago. Index of production for the week was 81.8.

February 13

Δ The Bureau of the Census reported that shipments of commercial steel forgings in December, 1960, totaled 89,400 tons compared with 92,624 tons in November, 1960 and 114,424 tons in December, 1959. Shipments for the year 1960 amounted to 1,268,267 tons compared with 1,373,801 tons in 1959.

Δ United Kingdom production of pig iron in 1960 totaled 16,654,000 net tons compared with 13,992,000 tons in 1959; production of steel ingots and castings in 1960 totaled 27,221,000 tons compared with 22,608,000 tons in 1959.

Δ The Bureau of Mines reports that consumption of scrap in December, 1960, totaled 3,739,000 gross tons compared with 3,939,970 gross tons in November, 1960. Pig iron consumption in December, 1960, amounted to 3,408,000 tons compared with 3,674,732 tons in November, 1960.

Δ The Commerce Dept. reported that retail sales in January, 1961, declined to a seasonally adjusted volume of $17,700,000,000, down two per cent from December, 1960, and January, 1960.

February 14

Δ Lukens Steel Co. reported for the year ending December 31, 1960 sales of $102,921,047, net income of $4,948,175 or $5.19 per share compared with 1959 sales totaling $83,067,363, net income of $2,598,496 or $2.27 a share.

Δ The Labor Dept. reported that workers drawing compensation in the week ended January 28, 1961, totaled 3,293,500 an increase of 61,500.

February 15

Δ F. W. Dodge Corp. reported that total construction contracts in the United States in 1960 amounted to $36,318,000,000, slightly above the 1959 total.

Δ The AISI reported that ingot and steel-casting production in January, 1961, totaled 6,424,000 net tons, compared with 5,839,841 tons produced in December, 1960.

Δ The Bureau of Statistics reports that Canadian steel production for the week ending February 11, 1961 was 110,519 tons, compared with 102,292 tons the previous week and 130,750 tons in the corresponding week of 1960.

February 17

Δ Detroit Steel Corp. reported sales for 1960 totaled $88,211,227, net income $4,585,615 equal to $1.15 per share, compared with 1959 sales of $116,712,000, net income of $11,500,274 equal to $2.90 per share.

Δ Industrial production in January, 1961, dropped to a seasonally adjusted 102 per cent of the 1957 average, compared with 103 per cent in December, 1960 and 111 per cent in January, 1960.

Δ Northwestern Steel and Wire Co. reported sales for the quarter ending January 31, 1961 of $15,221,101, net income $1,498,428 equal to 60¢ per share, compared with sales for the quarter ending January 31, 1960 of $23,487,655, net income $2,473,915 equal to 99¢ per share.

Δ The ARCI reported that deliveries of new freight cars in January, 1961, totaled 3515 compared with 4272 in December, 1960, and 2849 cars in January, 1960. Orders in January, 1961, totaled 1339, compared with 2705 in December, 1960, and 5742 in January, 1960. Backlog of cars on order as of February 1, 1961, totaled 13,871, compared with 21,070 on January 1, 1961, and 48,170 on February 1, 1960.

Δ Atlas Steels Ltd. reported sales for 1960 totaled $50,699,000, net income of $3,025,000 equal to $2.77 per share, compared with 1959 sales of $45,240,000 and net income per share of $3.02.

Δ The Aluminum Assn. reports shipments of aluminum sheet and plate in December, 1960, totaled 101,016,000 lb compared with 106,450,000 lb in November, 1960, shipments of aluminum foil in December, 1960, totaled 19,808,945 lb compared with 19,752,604 lb in November, 1960.

February 18

Δ The AISI reported that steel production for the week ending February 18, 1961, totaled 1,582,000 net tons (55.5 per cent of capacity), compared with 1,524,000 tons one week ago (53.5 per cent of capacity), and 2,674,000 tons one year ago. Index of production for the week was 84.9.

February 19

Δ The Japan Iron & Steel Federation reports that production of ingot steel in September, 1960, totaled 2,289,100 net tons; pig iron 1,269,400 net tons.

February 20

Δ Universal-Cyclops Steel Corp. reported 1960 sales of $111,467,124, net income of $4,352,622, compared with 1959 sales of $127,694,091, net income of $9,061,057. Sales for the quarter ending December 31, 1960 were $23,084,308, net income of $694,368, equal to 36¢ per share, compared with 1959 fourth quarter sales of $38,412,835, net income of $3,390,324 equal to $1.90 per share.

Δ Lone Star Steel Co. reported 1960 sales of $55,213,000, net income $2,348,000 equal to 60¢ per share, compared with 1959 sales of $112,944,477, net income $14,175,678 equal to $3.61 per share. Sales for the quarter ending December 31, 1960 were $8,592,837, with net loss of $1,564,000, compared with 1959 fourth quarter sales of $32,392,827, net income of $4,152,523 equal to 80¢ per share.

Δ The Bureau of the Census reported that net shipments of aluminum pig and ingot in December, 1960, totaled 152,000,000 lb compared with 133,000,000 lb in November, 1960. Shipments of aluminum mill products in December, 1960, totaled 225,000,000 lb compared with 237,000,000 lb in November, 1960.

February 21

Δ The Bureau of the Census reported that titanium ingot production in December, 1960, totaled 1,828,035 lb, compared with 1,879,502 lb in November, 1960. Shipments of mill products in December, 1960, totaled 1,186,309 lb, compared with 1,176,833 lb in November, 1960.

February 23

Δ Seven major steel producers cut supplementary unemployment benefits to laid-off workers; Bethlehem, Crucible and Youngstown reduced benefits to 60 per cent of normal for February, from 67.5 per cent in January. Republic, Armco, Wheeling and United States Steel, which paid 60 per cent in January, reduced benefits for February to 52.5 per cent.

Δ The Aluminum Assn. reports that production of primary aluminum in January, 1961, totaled 161,427 short tons, compared with 165,504 tons in December, 1960, and 164,024 tons in January, 1960.

February 24

Δ Mesta Machine Co. reported 1960 net income of $2,851,616 equal to $2.85 per share compared with 1959 net income of $5,205,801 equal to $5.21 per share. Mesta's order backlog as of December 31, 1960, was $65,200,000 compared with $71,500,000 as of December 31, 1959 and $49,400,000 as of December 31, 1958.

Δ Allis-Chalmers Manufacturing Co. reported 1960 sales of $530,019,036, net income of $10,583,211 equal to $1.12 per share, compared with 1959 sales of $539,640,773, net income of $22,864,963 equal to $2.47 per share.

February 25

Δ The AISI reported that steel production for the week ending February 25, 1961, totaled 1,582,000 net tons (55.5 per cent of capacity), compared with 1,582,000 tons one week ago (55.5 per cent of capacity) and 2,690,000 tons one year ago. Index of production for the week was 84.9.

February 27

Δ Eastern Stainless Steel Corp. reported 1960 sales of $61,804,598, net income of $1,782,758 equal to $1.24 per share, compared with 1959 sales of $66,945,144, net income of 3,148,131 equal to $2.19 per share.

Δ Crown Cork and Seal Co., Inc., reported 1960 sales of $121,211,000, net income of $3,407,000 equal to $3.15 per share, compared with 1959 sales of $123,191,000, net income of $2,643,000, equal to $2.38 per share.

February 28

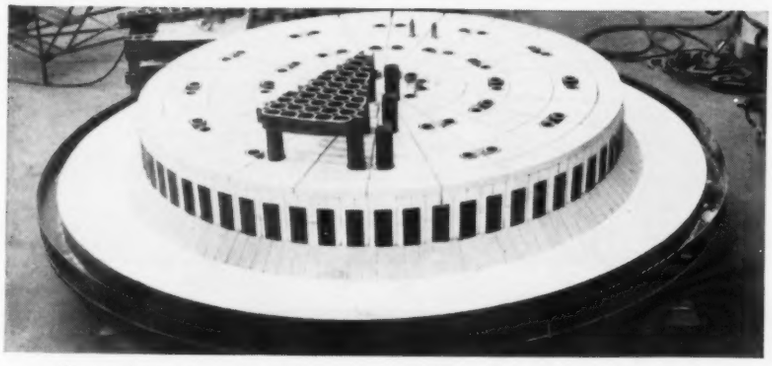
Δ F. W. Dodge Corp. reports that construction contracts let in January, 1961, totaled $2,485,000, compared with $2,192,949 in January, 1960.

Δ The Labor Dept. reported a decrease in consumer prices in January, 1961, to 127.4 per cent of the 1947–49 average, compared with 127.5 per cent in December, 1960 and 125.8 per cent in January, 1960.

Δ The British government will offer to investors $238,000,000 of state owned preference shares and debentures of seven steel companies in line with denationalization of the United Kingdom's steel industry.

Δ Blaw-Knox Co. reported 1960 sales of $192,810,000, net income of $4,200,000 equal to $2.20 per share, compared with 1959 sales of $161,294,808, net income of $5,830,788, equal to $3.04 per share.

New Alloy Supertherm* proves itself in 2300 degree fahrenheit brazing furnace



Supertherm hearth grid segment during furnace construction.

In a brazing furnace for the thrust chambers of rocket engines at Rocketdyne Division of North American Aviation, Inc., Canoga Park, Cal., a Supertherm furnace hearth grid assembly is operating at a temperature of 2300° F. The grid in a furnace built by the General Electric Company's Industrial Heating Department at Shelbyville, Ind., supports the engine parts during a brazing cycle of from five to eight hours with a maximum temperature of 2300° F. At this extreme temperature and under severe conditions of thermal fatigue created by the brazing cycle, *the Supertherm grid has performed successfully over one year.*

Supertherm is Electro-Alloys' new alloy for the 1800 to 2300 degree fahrenheit range. The composition of Supertherm is 26% chromium, 35% nickel, and is strengthened and stabilized with cobalt and tungsten. For technical information about the composition, physical and high temperature properties of Supertherm, fill out and return the coupon or contact your local Electro-Alloys representative.

*Supertherm is a patented alloy.

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Columbia-Geneva Steel Line showing the exit end looping tower.

• Three Annealing Lines by Aetna-Standard Division of Blaw-Knox have been installed in these divisions of United States Steel Corporation—Tennessee Coal and Iron at Fairfield, Alabama; United States Steel at Gary, Indiana; and Columbia-Geneva Steel, Pittsburg, California. The lines have many design features to improve tension control and tracking. High furnace speeds result in better production, quality and yield. A free loop before and after the furnace makes strip tension control much more accurate. At the entry and exit ends, loop towers provide abundant strip storage to insure constant furnace speeds. Scrap handling at the entry end has been improved. The lines handle coils up to 36,000 pounds, 72″ maximum diameter and 38″ maximum width. Maximum line speed—1500 f.p.m. For information write Aetna-Standard Division, Blaw-Knox Company, 300 Sixth Avenue, Pittsburgh 22, Penna.

Aetna-Standard Division

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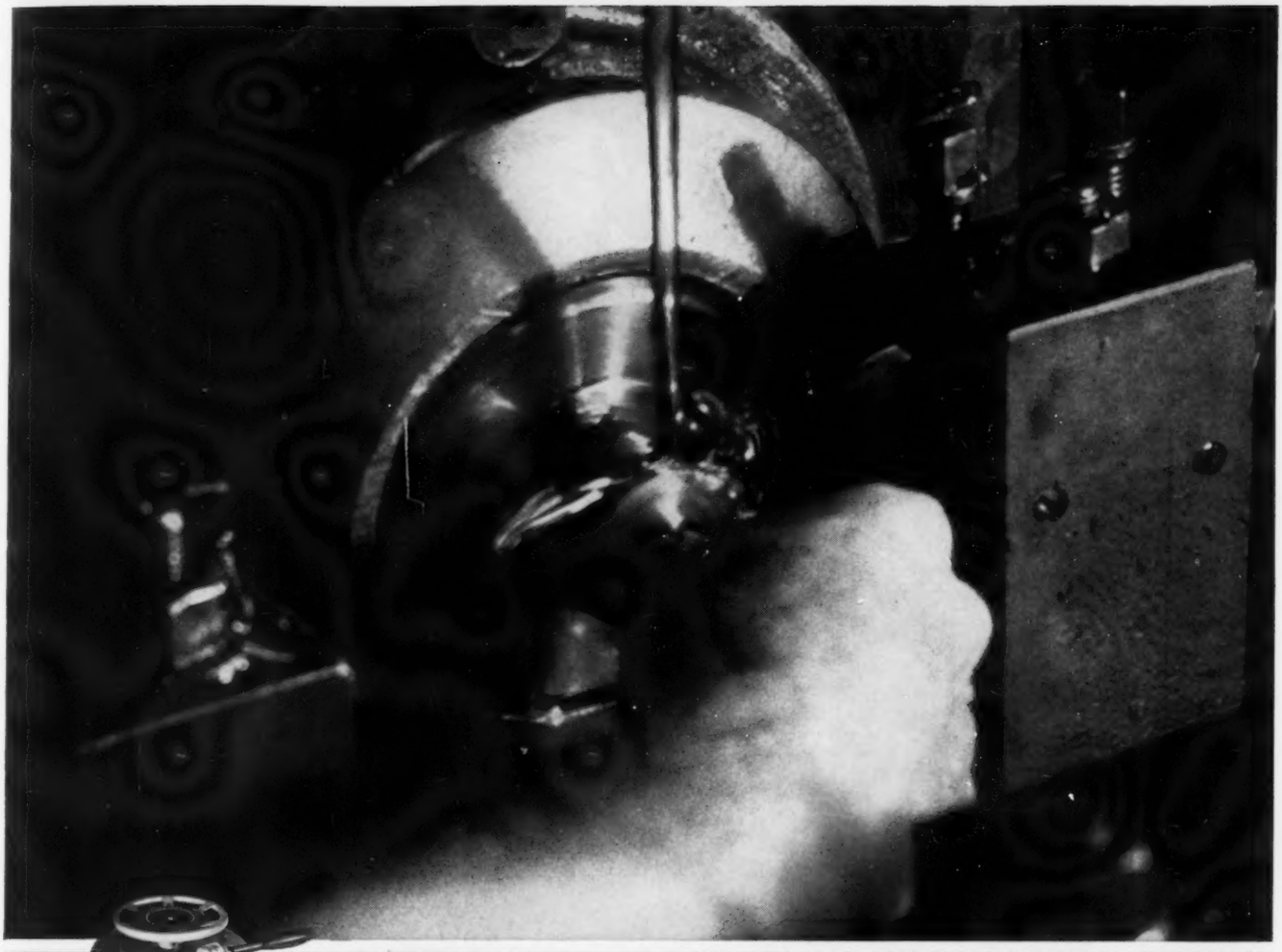

COOL CUTS

Keeping close tolerances is of prime importance at Diagraph-Bradley Industries, Inc., of Herrin, Illinois, leading manufacturer of stencil machines and accessories. One of the ways this is accomplished is by keeping cutting edges cool.

At Diagraph-Bradley stencil punches must be cut and held within .0005 of an inch—a fine point of precision Diagraph-Bradley attributes to the cooling and lubricating effect of Cities Service Chillo 10 cutting oil.

"You have only to take a Diagraph-Bradley machine," says one of the company officials, "cut a stencil with it and look at the resulting letter to realize how important the right cutting oil is to our production."

Cities Service Chillo 10 oil is a sulphochlorinated oil. The concentrations of sulphur and chlorine are stabilized by a special process, assuring uniformity of action through the entire cutting operation.

That's why, with Cities Service Chillo 10 cutting oil, work is always more accurate, clean and cool!

For full information call your nearest Cities Service office or write Cities Service Oil Company, Sixty Wall Tower, N.Y. 5, N.Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

National builds lifting magnets to stay in service.

The coils are *monolithic*, triple insulated and bonded with high-temperature, void-free resin.

They're watertight to prevent moisture reaching the coils. The plate is anchored to the magnet case with continuous welds around inner and outer edges.

They're rugged to withstand severe heat cycling and shock.

Check National for your lifting magnet requirements. For more information call Columbus plant... HUdson 8-1151... or the nearest National field engineer.

The Specialists in electric coils/repair service

National repairs magnets of any origin, size or shape.

Average Hot Lifting Capacity	55″ Pounds	65″ Pounds
Slabs, billets	53000	68000
Skull cracker balls	23000	38000
Machine cast pig	3000	3700
No. 1 heavy melting steel scrap	3200	3500
No. 2 melting steel	2000	3500
No. 1 machinery scrap (cast iron)	1700	2400
Cast iron borings	1700	2400
Steel turnings	1000	1200

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DIVISION OF McGRAW-EDISON COMPANY • COLUMBUS 16, OHIO

Electrical Engineers • Manufacturers of Electric Coils, Insulation, Lifting Magnets

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McGRAW EDISON

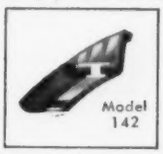
ENGINEERED OIL SEALS for Steel Mills

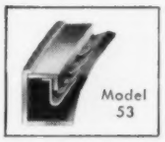
Garlock KLOZURE* Oil Seals (left) help keep lubrication in, dirt out of roll neck bearing at Inland Steel's East Chicago mill.

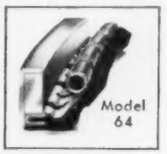
Inland Steel applies Garlock KLOZURE Oil Seals for protection of mill roll neck bearings at East Chicago.

Minimizing lubrication leakage from the inboard and outboard ends of the bearings, Garlock KLOZURE Oil Seals provide more constant service as the rolls change position in a lateral movement during operation. Inland finds, too, that in atmospheres of dirt, scale and spray, KLOZURE Oil Seals help keep foreign particles from entering—and damaging—the bearings.

For good, economical bearing protection, Inland joins the growing list of steel producers who use Garlock KLOZURE Oil Seals. Wherever you look in mills, you'll find a specific type of KLOZURE Oil Seals doing a specific job. Model 142, for instance, helps keep water splash and scale out of bearings at the shoulder of mill rolls. Models 64 and 82 protect bearings on back-up and work rolls. Model 53 is recommended for table rolls at normal and high speeds. Model 23 Split KLOZURE is ideal where equipment cannot be dismantled too easily.







Designed for peak efficiency and durability, Garlock KLOZURE Oil Seals resist oil and grease, are impervious to water, mild acids, alkalies, withstand temperatures from −40°F to +250°F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500°F.

If you have a particular sealing problem, why not discuss it with your Garlock representative. He's backed by over 70 years of experience in engineering, production and application. Call him at the nearest of the 26 Garlock sales

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Industry News...

OXYGEN PLANT UNDERWAY FOR SPARROWS POINT

△ A $6,000,000 oxygen-nitrogen producing facility is under construction at the Sparrows Point, Md., plant of Bethlehem Steel Co. by Air Products, Inc. When completed by midyear, the plant will supply 350 tons per day of high purity oxygen and 450 tons per day of high purity nitrogen. This facility will produce oxygen and nitrogen in both liquid and gaseous forms.

The new plant, which is being built and will be owned and operated by Air Products, will be located adjacent to the Bethlehem works. The oxygen will be injected into the open hearth furnaces through roof lances. Production will be increased because oxygen speeds the removal of carbon and other impurities in the steelmaking process. The high purity nitrogen will be used for sheet steel annealing operations in the mill.

In 1948 Air Products installed the first of a number of on-site plants for Bethlehem at Sparrows Point. With later additions, production capacity reached 42 tons per day of oxygen in 1956. With the new plant, Bethlehem's oxygen capacity will be nine times greater.

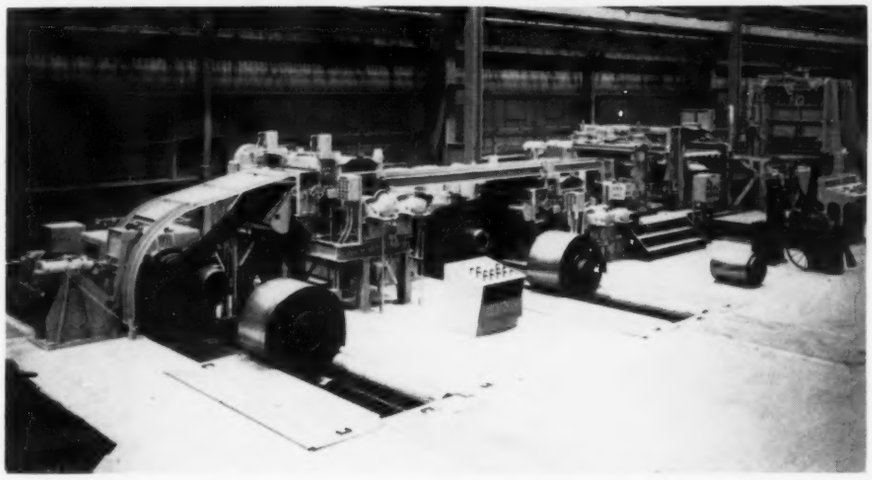
In addition to the Sparrows Point requirements, the plant will also supply Bethlehem Steel's Steelton, Pa., works 100 miles away. Liquid oxygen will be transported in over-the-road trailers and converted into gaseous oxygen for use in the steelmaking and steel fabricating shops at Steelton.

MIDWEST STEEL AWARDS SALEM-BROSIUS CONTRACT

△ Midwest Steel Corp., division of National Steel Corp., has awarded Salem-Brosius, Inc., a contract for the design and erection of four coil annealing furnaces, including five hoods and 15 bases. Each unit will anneal four coils of 72-in. diam, stacked to a height of 14 ft. The units are radiant tube fired for heating to 1350 F.

The installation will be instrumented for automatic control of temperature, combustion and other operating characteristics.

GALVANIZING LINE COMPLETED AT MIDWEST STEEL



Photograph shows terminal point of the high-speed continuous galvanizing line recently installed at the Portage, Ind., plant of Midwest Steel Corp., Division of National Steel Corp. The line is 915 ft long and operates with speeds up to 300 fpm. It can receive coil steel up to 90,000 lb in weight. Installation of the Aetna-Standard line was handled by the David W. Murray Co. In addition, Murray is completing the installation of an Aetna-Standard annealing line in this same plant.

NEW OXYGEN PLANT TO SERVE JOHNSTOWN PLANT

△ Air Reduction Sales Co. has announced the signing of a contract with Bethlehem Steel Co. for the construction and operation of a tonnage oxygen plant, the steel industry's largest single-column air separation facility, to supply Bethlehem's blast furnaces at Johnstown, Pa.

Construction of the plant has begun and completion is scheduled for September, 1961. With a production capacity of 675 tons of oxygen per day, the plant represents an investment in excess of $5,000,000.

A pipeline will carry the oxygen to Bethlehem's ferromanganese blast furnaces. For emergency needs, facilities will be constructed for the storage of 400 tons of liquid oxygen and eight tons of high pressure gaseous oxygen. Air Reduction will own and operate the plant.

Situated on a five-acre lot, Air Reduction's air separation facility will include a building 80 x 100 ft, containing control and electrical compression equipment, and a cold box 50 x 75 ft and 60 ft high, containing low temperature air separation equipment. The main air compressor will be driven by a 9000 hp motor.

The plant will process 66,000 cfm of air to separate the oxygen by low temperature methods. The interior of the cold box will be insulated against outside temperatures by 600,000 lb. of rock wool.

At the Johnstown plant, 600 tons of oxygen a day will be used for atmosphere enrichment in blast furnaces and 75 tons a day will be higher purity product for cutting, scarfing and other special uses.

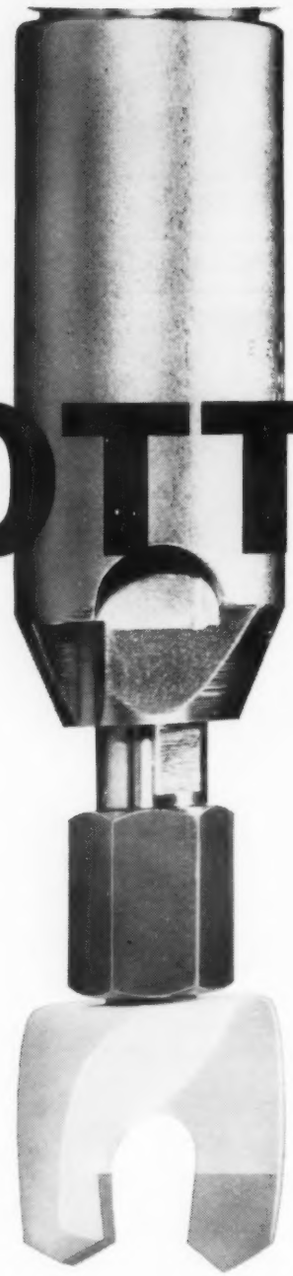
NEW ANNEALING LINE OPERATING AT WEIRTON

△ A new continuous cleaning and annealing line has been placed in production in the Tin Plate Department at Weirton Steel Co., division of National Steel Corp.

to clean badly clogged air preheater tubes

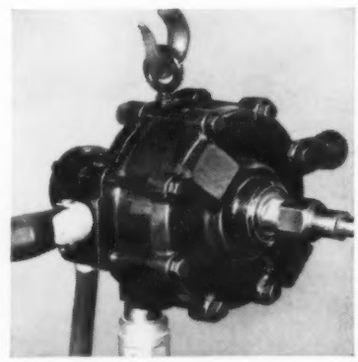
ELLIOTT

heavy duty tube cleaner



Shown above is the powerful Lagonda heavy-duty air motor with carbide-tipped cutter bit. Attached to a flexible air hose, this unit can operate in any position where headroom is limited. The carbide tip will clean even the most badly clogged tubes, quickly and effectively.

Where headroom permits, the heavy-duty suspended-type motor shown at the right can be used to drive a cutting bit attached to a hollow steel shaft, through which flushing and cooling water is fed. This extremely powerful unit can be used either vertically or horizontally.



Full information and prices may be obtained from any Elliott District Sales Office, or by writing Elliott Company, Lagonda Plant, Springfield, Ohio.

Y 1-1

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GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio

TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS
DEAERATING HEATERS • EJECTORS • CONDENSERS • STRAINERS • TUBE CLEANERS

This is the second such installation at Weirton.

The line, located in an existing building that is 560-ft long, 122-ft wide, and 110-ft in height, handles 60,000-lb coils of cold rolled strip steel up to 45-in. wide in tin plate gages, and operates at speeds up to 2000 fpm.

Steel coils from the tandem mills go to the new line, which can clean and anneal 60 tons of strip per hour, and from there are transported to the skin rolling and tin plating departments.

In the continuous annealing process, it is necessary to provide sufficient looping in the strip at the entry end of the annealing furnace to permit the welding of coil ends without stopping the steel passing through the furnace. Looping must also be provided for at the exit end for alternately changing the winding reels so the line may continue to operate without stopping in the furnace while coils are removed.

Ordinarily this process is accomplished in looping towers above the working floor level at both ends of the line. However, since the new line at Weirton is located on the fourth floor of the building the looping towers will go down through the building to the basement floor, permitting the looping of 1200 ft in the first tower and 800 ft in the second tower.

The entire structure is carried on concrete foundation supported on rock base, with column loads approximately 4,000,000 lb each.

The present building, constructed of insulated panel, is designed for the future addition of one more continuous cleaning and annealing line making a future operation of three lines.

SHARON STEEL ADDING VACUUM DEGASSING UNIT

△ Ground was broken February 27 by Sharon Steel Corp. for a new vacuum stream droplet degassing unit which, company officials said, will provide the Sharon's customers with the highest quality forging steel in the most complete range of sizes and grades available.

Scheduled for production in six months, the new unit will be the second major installation to be undertaken in the first half of 1961.

QUALITY AND PERFORMANCE

Two reasons why steel men specify Morgan cranes!

• Performance records prove conclusively that advanced design and heavy-duty construction of Morgan cranes make them less costly to operate and maintain.

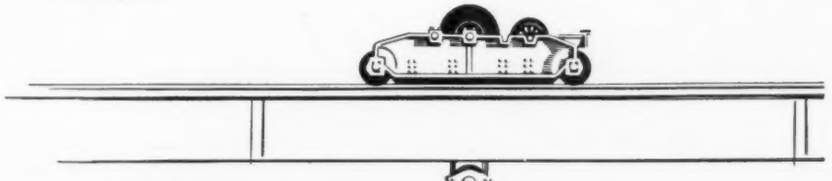
These slab-handling cranes, recently installed in a new Eastern mill, were specified because of the features that make Morgan cranes best in the business.

You get this same performance in all steel mill equipment built by Morgan. The next time you buy equipment, let a Morgan representative show you how to save the most by buying the best . . . Morgan!

One of two Morgan 50/20 ton, 6-motor, 85' span, special double hoist, heavy duty mill type, slab-handling cranes recently installed in Eastern steel mill.

ELECTRIC OVERHEAD CRANE INSTITUTE E.O.C.I. MEMBER

The Morgan Engineering Company, founded in 1868, manufactures overhead electric traveling cranes, gantry cranes, open hearth special cranes, plate mills, blooming mills, structural mills, shears, saws, and auxiliary equipment.



THE MORGAN ENGINEERING CO. *Alliance, Ohio*

FIRST . . . IN MEASUREMENT AND CONTROL OF MATERIALS FLOW

Do blending errors and equipment failures reduce your profits through shutdowns and replacements? If payloads were dollars, would you settle for accuracy based on intermittent feeding? B-I-F's performance-proved coal blending system weighs and controls every pound of coal, has unlimited capacity, and maintains an accurate preset blend.

Free Facts

Continuous feeding and blending saves material, reduces cost, improves quality . . . results in bigger processing profits.
Write for free — Facts today!

BIF Industries

BUILDERS-PROVIDENCE • PROPORTIONEERS • OMEGA
547 HARRIS AVENUE, PROVIDENCE 1, RHODE ISLAND

Earlier in the year, the company announced it was installing a million dollar bright anneal plant for the finishing of stainless steel.

Plans for the vacuum stream droplet degassing unit call for a 75-ft extension to the electric furnace building at the Roemer works. It will be located at the pouring aisle level which is 25 ft below the melt floor.

Two steel tanks, each having a diameter of 17 ft and a height of 29 ft will be located in this extension. The vacuum tanks will be connected by 48-in. exhaust pipe to multi-stage steam jets located outside of the building.

Two types of operations are planned. By the first method ingot molds will be placed in each tank. The tanks will then be covered and sealed. Air will be exhausted from the tanks. Steel will be poured from a 100-ton electric furnace into a ladle. The ladle will travel by crane to a position over the tank. The bottom of the ladle will then be sealed to the tank cover. In pouring, a disk in the top of the tank cover will be penetrated, the pour thereafter providing its own sealing action.

During pouring the stream will break up into small droplets, releasing hydrogen and other gases from the molten steel. When the pour is complete, nitrogen gas will be bled into the tank to break the vacuum.

When the first ingot mold has been filled the crane will move the ladle to the second tank. Ingot molds will be cooled in normal atmosphere and the ingots removed.

The second method planned is to pour from one ladle into another. Under this method a ladle will be placed in one tank and the tank will be placed under vacuum. The pouring will release gases from the steel as described. Ladle additives can be introduced into the vacuum chamber at this time.

NEW TANDEM COLD MILL NOW OPERATING AT FORD

△ The first 50,000-lb coil of strip steel has been put through a newly-installed four-stand tandem cold rolling mill at Ford Motor Co.'s Rouge plant in Dearborn, Mich.

The mill can reduce thickness of steel strip from coils up to five ft

VALUED FOR
Performance

TM
alloy slings

Consistent, full-duty performance is routine for TM Alloy Slings. That's why they are preferred for heavy material handling in all types of industry. Controlled heat-treating . . . brute strength . . . and scientific quality control, all have an important bearing on this enviable record. Call your distributor, steel warehouse, hardware wholesaler or write for Bulletin 14A.

S. G. TAYLOR CHAIN CO., Inc.
Plants: Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

Prompt repairs on alloy slings in both plants.

Taylor Made CHAIN SINCE 1873

8 NEW VOSS LEVELERS AT U. S. STEEL!

VOSS VERSATILITY DEMONSTRATED IN LEVELER APPLICATIONS AT U. S. STEEL

The United States Steel Corporation has been using Voss Levelers for many years. During the past 2 years, U. S. Steel has again shown its confidence in Voss by ordering *eight new levelers* for installation in various plants. The applications are varied, ranging from galvanized and cold-rolled to plate and high-yield missile stock. Exclusive patented Voss principles enable *all* users to get better than stretcher-level flatness under most conditions, and at high production speeds . . . results unobtainable with any other leveler.

Voss Inverted Roller Levelers are designed for ferrous and non-ferrous metals in a wide variety of applications. Let Voss put 30 years of leveling experience to work for you.

HERE'S THE RUN-DOWN:

INSTALLED:

GARY SHEET AND TIN MILL
Application: Tin Plate **Installed:** 1958

IRVIN WORKS
Application: Cold-rolled Shear Line **Installed:** 1959
Application: High-Speed Galvanizing Line **Installed:** 1960

VANDERGRIFT WORKS
Application: High-yield Missile & Stainless Steels
Min: .062 **Max:** .1875 **Installed:** 1960

ON ORDER:

GARY SHEET AND TIN MILL
Application: Hot and Cold-rolled Steel Plate
Min: .062 **Max:** .250, 75" width **Installation:** Late 1960

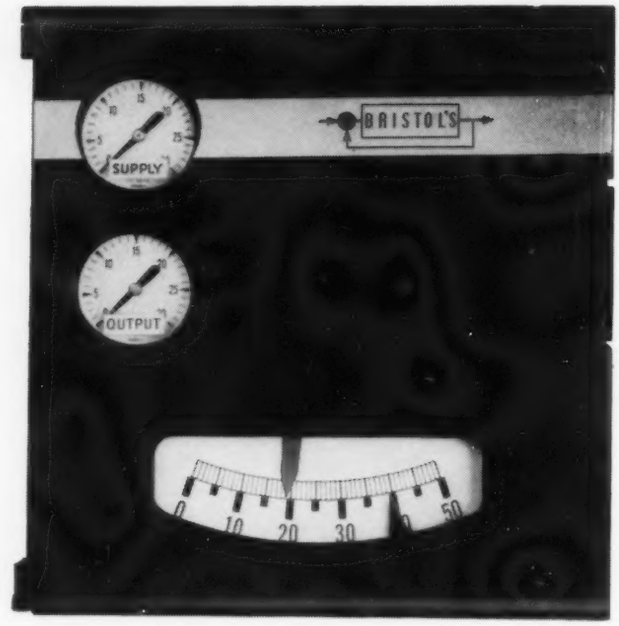
IRVIN WORKS
Application: Cold-rolled Shear Line **Installation:** Late 1960

COLUMBIA-GENEVA DIVISION
Application: Cold-rolled Shear Line **Installation:** Early 1961
Application: High-Speed Galvanizing Line **Installation:** 1961

Voss ENGINEERING CO.

7301 Penn Ave. Pittsburgh 8, Pa. Churchill 2-4422

NEW BRISTOL'S



Series 624 A/D* pneumatic controller features simplicity and high control stability

- **Simple modular design for ease of servicing**
- **High control stability for closer process control**
- **Designed for batch-type and continuous processes**
- **Proportional and proportional-plus-reset control models available**

Top control performance with maximum simplicity plus standard Bristol precision measuring elements—those are the key features of the Bristol Series 624 Controller. The 624 uses the same renowned elements that have earned such a reputation for accuracy and dependability on other Bristol automatic controlling and recording instruments—perfected through wide experience and many years of development.

Self-contained modular design of the control unit speeds servicing. The whole modular unit, consisting of an aluminum casting with working parts made of stainless steel, Ni-Span C, and Neoprene diaphragms, can be removed by taking out only two screws and a link.

Outstandingly compact, the aluminum instrument case (only 8" x 8" x 5" overall) is completely weatherproof. It is designed for either flush, surface, panel, or valve mounting. Attachments for pipe mounting (2-inch pipe) are available. Write for complete data on the versatile and economical 624 A/D. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn. 0.35

Advanced Design

CONTROLLERS OFFERED FOR:

PRESSURE AND VACUUM: Ranges from full vacuum to 10,000 psi.

TEMPERATURE: Ranges from —100°F to +1000°F.

FLOW AND DIFFERENTIAL PRESSURE: With mercury-type manometer and dry-type differential unit.

LIQUID LEVEL: With bulb unit and mercury manometer and dry-type differential unit.

HUMIDITY: Zero to 100% relative humidity.

CONTROL UNIT CHARACTERISTICS:

PROPORTIONAL BAND: 0-400% continuously adjustable, direct- or reverse-acting.

RESET: 0.1 to 50 repeats per minute.

AIR PILOT: Non-bleed type.

PILOT CAPACITY: 3.0 scfm.

FREQUENCY RESPONSE: Flat to 300 cycles per minute.

TEMPERATURE STABILITY: Less than 0.25% change in the output pressure for 90°F temperature change.

MATERIAL: Aluminum housing; 316 stainless steel internal parts; Ni-Span C feedback element.

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

in width, passing the steel through rolls at a speed up to 3200 fpm. It is one of the fastest and most powerful four-stand cold reduction mills devoted to automotive body steel.

After the strip has passed through the rolls, the cold-rolled coil is wound on the tension reel at the delivery end of the mill. Here, a hydraulically operated transfer carriage carries it horizontally to the delivery conveyor. All movement of coils throughout the operation is controlled automatically.

The mill is equipped with nine drive motors totaling 22,000 hp. Each of the four stands and the coil reel at the discharge end have an individual drive. Power to drive the mill consists of two motor generator sets, each comprised of two 4000 kw generators and driven by one 11,000 hp motor.

An automatic gage control system operates throughout the cold-rolling operation to regulate and measure the thickness of the steel strip moving through the mill. Coarse gage controls are located at the No. 1 stand. Finish gage regulation and measurements of thickness are made as the steel passes the No. 4 stand.

"Pressductor" force gage instruments are incorporated in all stands to show the force being exerted on the steel strip as it passes between the work rolls of each stand.

Three "tensiometers" are located between the stands of the mill to indicate the amount of tension on the steel strip as it is uncoiled from the entry end, passes through the stands and is recoiled at the discharge end.

The new mill is completely equipped with synchronized uncoiling and recoiling facilities, entry and delivery conveyors for handling the coils, and an upender which transfers the coils at right angles from the delivery conveyor to the storage conveyor.

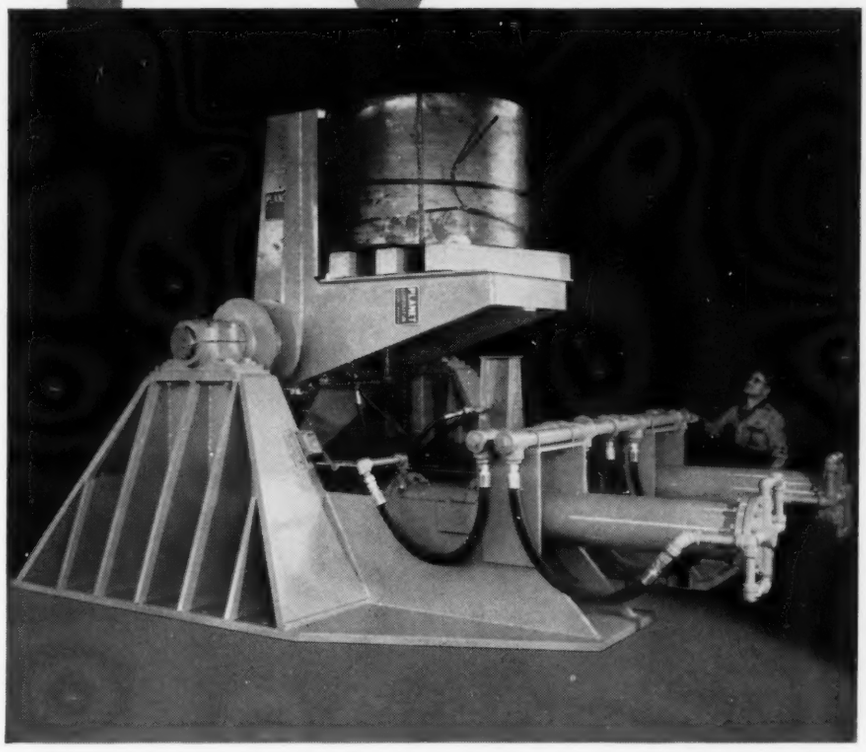
Coil conveyors, each of a different type, handle the coils of strip to and from the mill.

Meetings

△ The American Foundrymen's Society 65th Castings Congress is scheduled to be held May 8–12 in San Francisco, Calif.

PV

PLANET VERSATILITY...



HEAVY DUTY UPENDER

TURNS 50,000 LB. STEEL COIL

Planet Corporation's Upender is another example of why Planet is known throughout industry as a versatile organization ... and as an organization which manufactures quality equipment. Planet's Upender turns 50,000 pound coils from a horizontal position to vertical, or vice versa, and it is made to take day in, day out abuse. Although upenders are not unique (as is most of Planet's equipment) it is evidence of Planet's competence in creating and building even the heaviest of materials handling equipment.

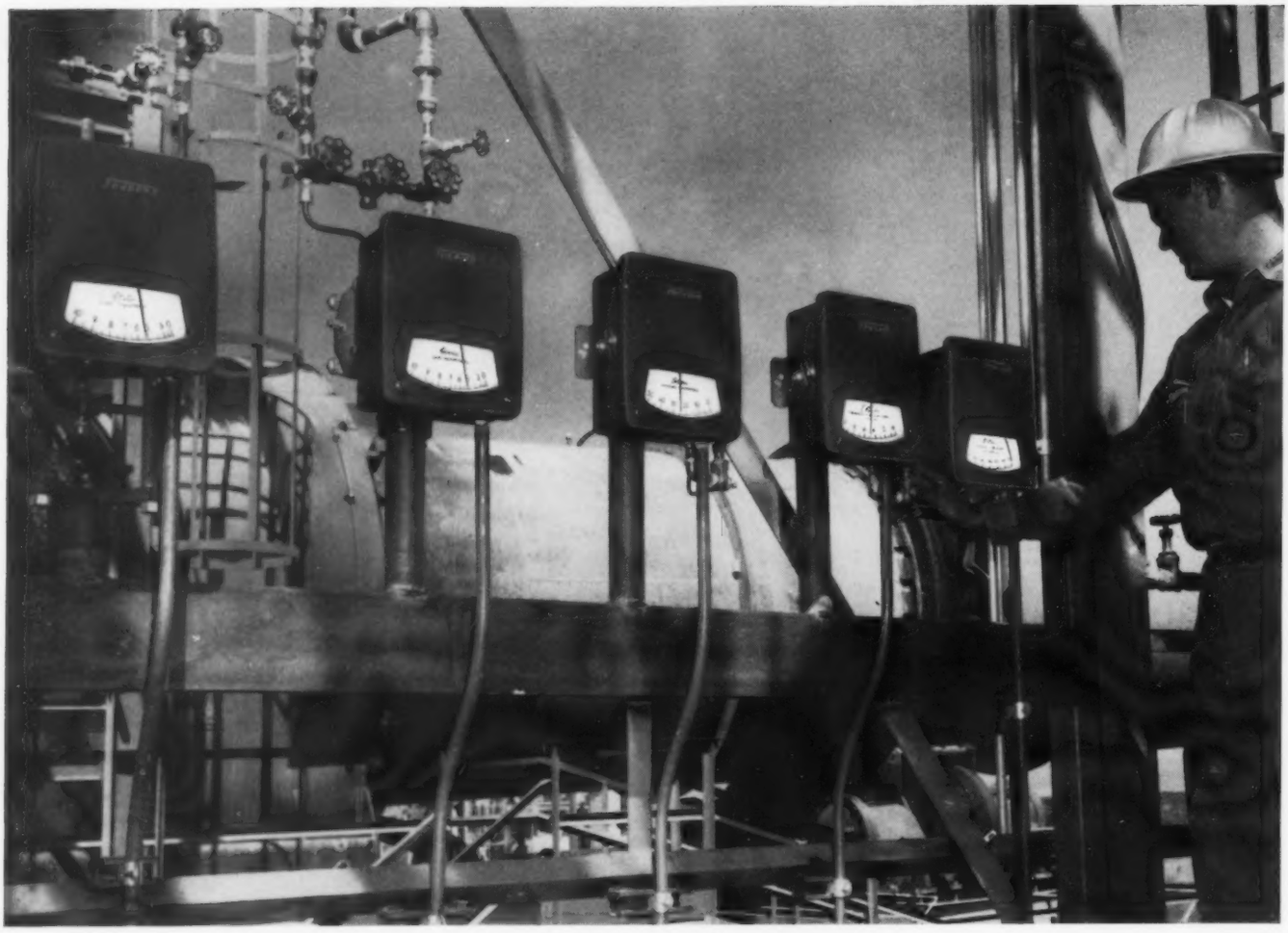
PLAN WITH PLANET If your plant has a production, materials handling, or automation problem, let Planet demonstrate how its versatile engineering skill, and production and erection know-how can help you. It has paid many leading industrial concerns whose names are household words to "Plan with Planet" ... *it will pay you too to use Planet Versatility.* Write or phone today!

PLANET CORPORATION

1816 SUNSET AVENUE
LANSING, MICHIGAN

- ENGINEERED HANDLING SYSTEMS
- AUTOMATION EQUIPMENT
- FOUNDRY HANDLING EQUIPMENT

92



Type 630 indicating electronic Consotrol transmitters may be equipped with any standard Foxboro measuring element. Transmitters continue to measure and indicate even in event of power failure.

Temperature, flow, pressure, level – Foxboro Electronic Transmitters will measure and transmit them any place wires can go

FOR DISTANCES up to several miles, Foxboro Electronic Consotrol* Transmitters are the fastest, most accurate way you can transmit a measured variable.

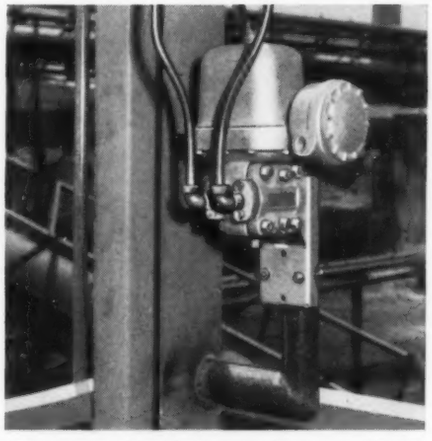
There's no transmission lag. Electric signals are transmitted instantly over two small, unshielded wires to centrally-located recorders and controllers.

Both the Foxboro Indicating and Force-Balance Electronic Transmitters have no vacuum tubes to burn out. Instead, dependable, solid-state components are used throughout to insure years of trouble-free operation.

Zero and span settings are simple mechanical adjustments. And your present personnel will need no special training or skills to operate them.

Foxboro Electronic Transmitters can be mounted anywhere — in any position. Heavy-gauge, tight-gasketed cases completely protect them from dust, dirt, and weather.

Ask your Foxboro Field Engineer how they can help improve the efficiency of your operation. Or write for Bulletin 21-10 — it tells the whole Electronic Consotrol story. The Foxboro Company, 583 Neponset Ave., Foxboro, Massachusetts.



Type 613 d/p Cell* transmitter combines simplicity and accuracy of force-balance with speed and convenience of electrical transmission. Requires no power supply at the transmitter.

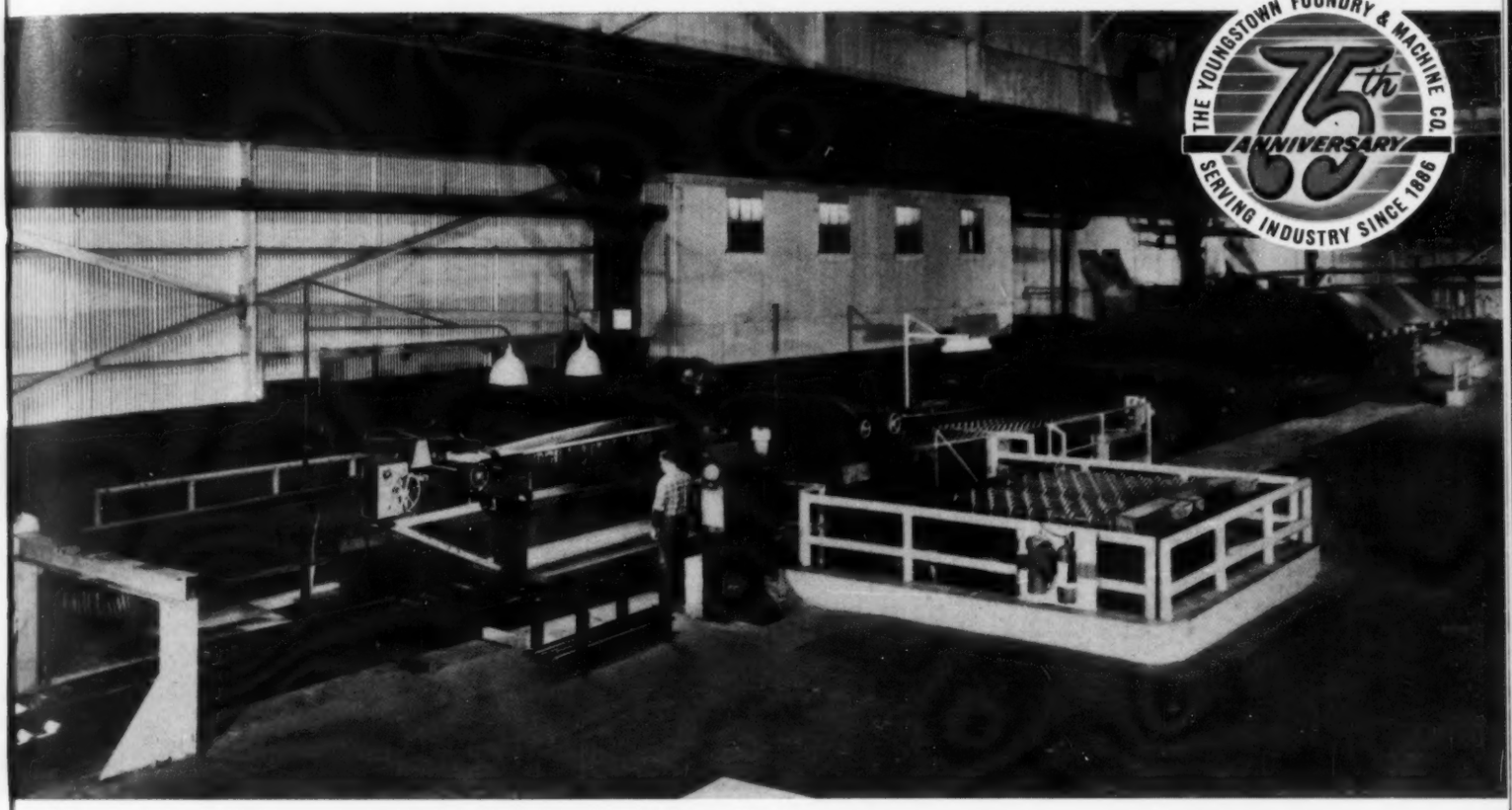
Reg. U. S. Pat. Off.

FOXBORO

REG. U. S. PAT. OFF.

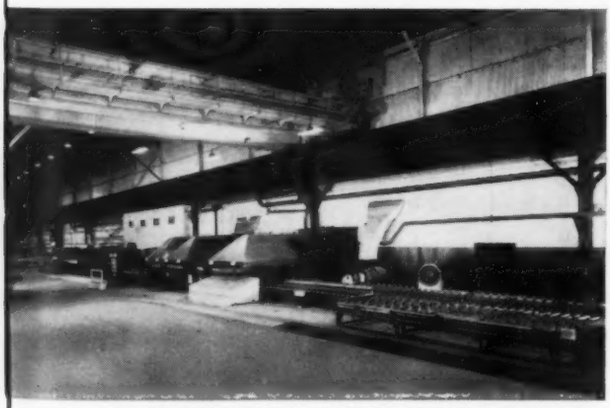
"YOUNGSTOWN"

81" SHEET SCRUBBER LINE



...built for United States Steel's Irvin Works

Dravosburg, Pa.



Entry end of "Youngstown" 81" sheet scrubber line at United States Steel's Irvin Works.

This ultra modern 500 fpm scrubber line is designed to increase tonnage per turn, in cleaning steel sheets up to 76" wide and .250" thick.

The line was furnished complete including unloading conveyor, skew conveyor, acid spray unit, water spray unit, alkali spray unit, hydro scrubber unit, sheet dryer, cooling system and conveyors, and all auxiliary equipment including acid proportioning, dry met, fume exhaust system, electric motors and controls, air conditioned electrical control station, installation, erection, and foundation engineering.

You can rely on "Youngstown's" 75 years of scrubbing, pickling and cleaning know how. Your inquiries are invited whether you require a complete turnkey installation or any auxiliary component.

The Youngstown Foundry & Machine Co.

Youngstown 1, Ohio

Two 75-ton Cranes built by Browning for heavy steel mill service

BROWNING CRANES for Steel Mill Service and General Industrial Service

Electric Overhead Traveling Cranes
Electric Brakes
Buckets
Electric Revolving Machines
Special Trolleys

Browning cranes are designed and built specifically for heavy duty mill type and industrial service. Mill type cranes meet or exceed AISE requirements. We build into every crane whatever special features, mechanical or electrical, which you may desire.

Information worth your having:

(1) our complete well illustrated catalog describing Browning cranes, trolleys, brakes, hook blocks;
(2) separate bulletin on Browning brakes.

VICTOR R. BROWNING & COMPANY, INC.

WILLOUGHBY (CLEVELAND), OHIO

EMPTY OPEN BOTTOM HOPPER CARS EASILY, SAFELY, QUICKLY

SYNTRON VIBRATORY CAR SHAKERS

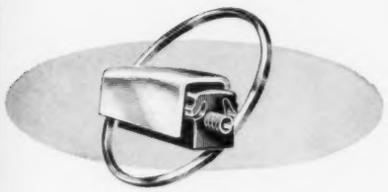
GIVE TOP PERFORMANCE WHEN MOUNTED ANYWHERE ALONG THE LENGTH OF ANY SIZE OPEN BOTTOM HOPPER CAR

Whether your operation requires emptying one car a week or many cars per day, a Syntron Car Shaker will reduce labor cost and demurrage. Syntron Car Shakers transmit powerful vibrations throughout the car to loosen and shake the compacted material down through the open hopper gates. Syntron Car Shakers feature —Rotary Vibrator Unit, powerful, weatherproof, produces 900 vibrations per minute, simplicity of design—counterweight simplifies mounting and operating, permits mounting over either light or heavy flanged frame. One man can easily install and operate this Car Shaker with complete safety. No need to get in, on, or under car. All of Syntrons' vast experience with Vibratory equipment contributes to the effectiveness of this unique Car Shaker. Syntron Engineers are available to discuss the details of each application.

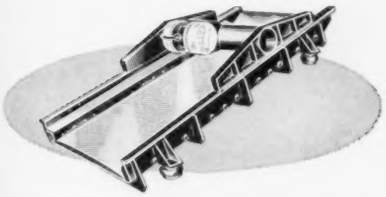
For further information in detail write for a Syntron Catalog

SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON SYNTRON

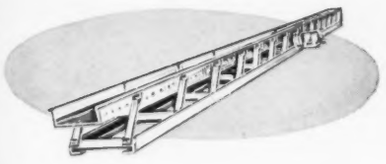
Other SYNTRON equipment of proven dependable quality



Roll Neck Seals

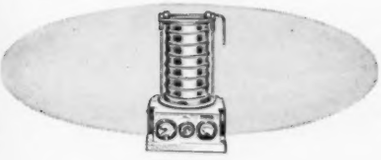


Vibrating Screens



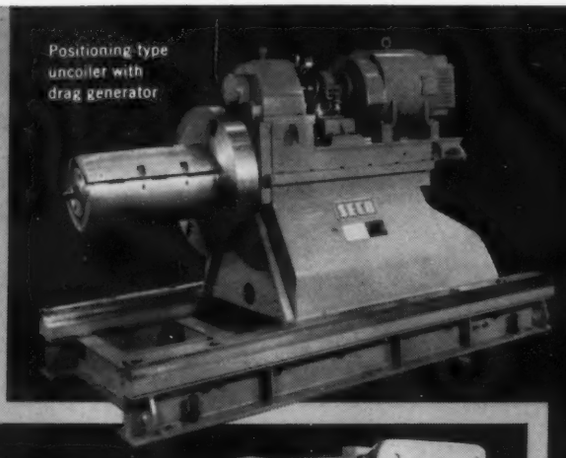
Mechanical Vibrating Conveyors

Lapping Machines



Test Sieve Shakers

SYNTRON COMPANY
699 Lexington Avenue • Homer City, Pa.

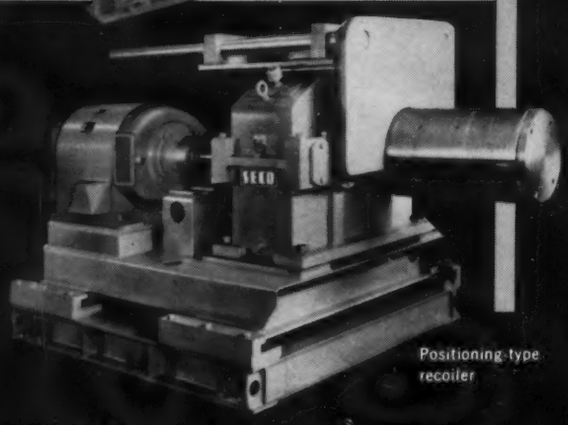


Predictable Performance

for processing lines with

SECO

terminal equipment

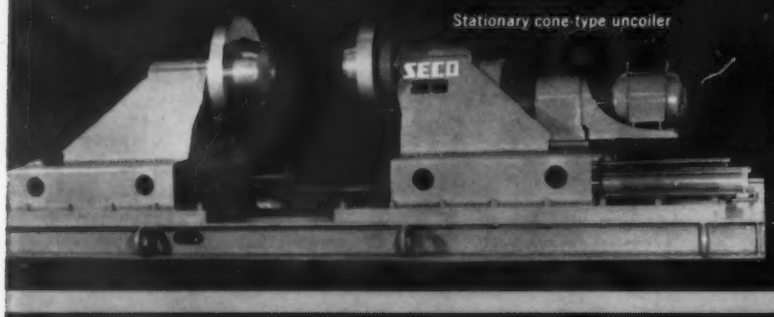


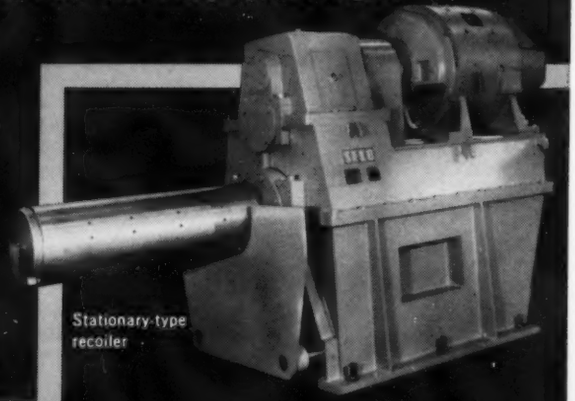
From entry to exit, new and modernized processing lines . . . annealing, pickling and others . . . perform better with SECO terminal equipment. This equipment handles coils ranging from 10,000 to 50,000 pounds with speed, convenience, safety.

SECO uncoilers and recoilers are designed to operate at any speed the mill requires, are available in positioning or stationary types. The positioning types feature a slideable reel base mounted on a sub-base for alignment with the processing line, actuated by an automatic edge control.

SECO also makes auxiliary equipment such as coil cars with coil lifts to simplify uncoiler loading and recoiler unloading. Available for mandrel or cone-type reels.

A staff of trained sales engineers will assist you in finding the equipment best suited to your needs. Call or write today. West Coast representative: United Machine Tool Company, Los Angeles.





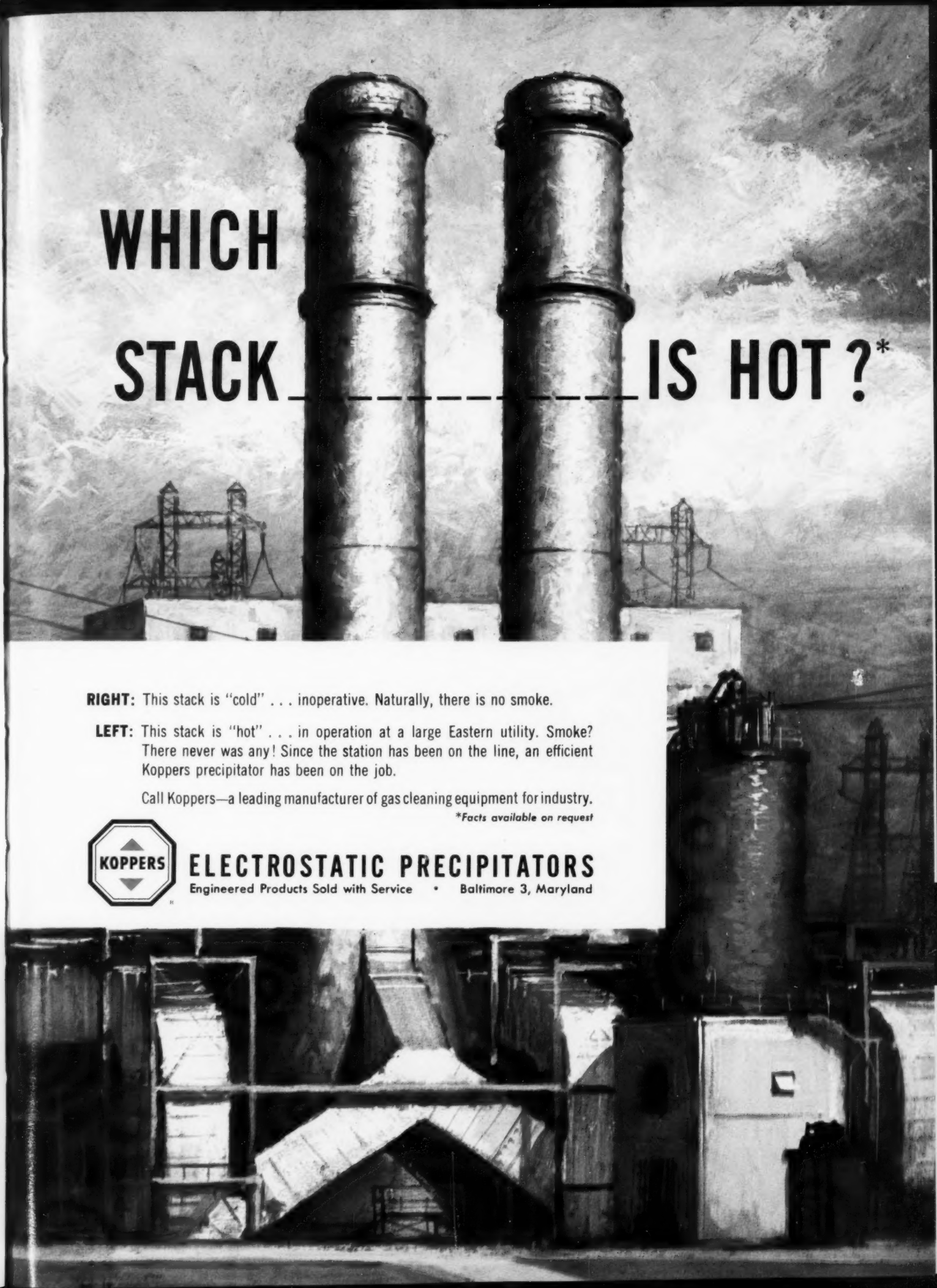
SECO STEEL MILL EQUIPMENT

- Leveling and Shearing Lines
- Combination Edging and Flattening Lines
- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
- Slitting Lines
- Multiple Strand Pull-out Rolls and Take-up Frames
- Strip Coilers (Up and Down Type)
- Traverse Reels for Narrow Strip
- Steel Coil Up-enders
- Scrap Ballers

Affiliated with Lee Wilson Engineering Co., Inc.

STEEL EQUIPMENT COMPANY

P. O. BOX 737, WARRENSVILLE STATION • CLEVELAND 22, OHIO



RIGHT: This stack is "cold" . . . inoperative. Naturally, there is no smoke.

LEFT: This stack is "hot" . . . in operation at a large Eastern utility. Smoke? There never was any! Since the station has been on the line, an efficient Koppers precipitator has been on the job.

Call Koppers—a leading manufacturer of gas cleaning equipment for industry.

**Facts available on request*

KOPPERS

ELECTROSTATIC PRECIPITATORS

Engineered Products Sold with Service • Baltimore 3, Maryland

A Rex Coil Conveyor System in a large steel producing plant.

why REX® coil conveyor chain keeps DOWN TIME down

Years of dependable service in many rugged mill applications is proof that Rex Coil Conveyor Chain is a top runner in slashing down time and maintenance costs.

Reason is this: Rex engineers were not satisfied with a "me too" chain. They turned to basic research to give this chain the ability to take it. They selected the materials and the design that would assure the most efficient combination of strength, wear life and economy—used heavy-duty antifriction roller chain to supply smooth operation—attached rugged platforms for a steady, level carrying surface. And over 70 years of CHAIN Belt manufacturing experience, plus rigid quality control, makes sure Rex Chains perform as planned.

Write CHAIN Belt Company, 4693 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: Rex Chainbelt (Canada) Ltd., Toronto and Montreal.

REX®
CHAIN BELT COMPANY

REX IS BEST . . . IN THE USER TEST

Publication Service...

MARCH, 1961

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Silicones

A comprehensive booklet on silicones has been issued by the Silicones Div. of Union Carbide Corp. The booklet goes into detail about what silicones are, describes their manifold uses for consumer and industrial products, and suggests ways in which they can be adapted to a host of new applications. A feature is the series of charts covering silicone fluids, resins, rubber compounds, water repellents, anti-foams and emulsions and their adaptability for use by the aviation, automotive, chemical, electronic, rubber, paint, paper, textile, glass, metal working and other industries.

(2) Goggle Valves

The Metal Products Div. of Koppers Co., Inc., has published a brochure on the design, operation and specifications of goggle valves. The valves are for use in steel mill gas mains and will be made in a range of sizes to fit gas mains from 24 in. in diam to 108 in. The valve features all-welded, stress relieved valve bodies and the goggle plates and plate seats are replaceable while the valve is in service.

(3) Heat Exchangers

A new bulletin describing two standard heat exchangers is now available from American-Standard Industrial Div. This bulletin discusses applications and engineering features of these heat exchangers which have straight tubes, externally packed floating tube sheets, removable bundles and single or two-pass design. Typical applications include lube oil coolers and jacket water coolers for internal combustion engines and for compressors; electrolyte coolers for liquid rheostats; heat exchangers for boiler blowdown or contaminated condensate; inter and after coolers for air compressors, brine coolers; gland seal steam condensers for turbines; and coolers for turbine oil, seal oil, hydraulic coupling fluid and hydraulic circuit oil or fluid. (Bulletin No. 302 1K1)

(4) Heavy Duty Blast Cleaning Barrels

Heavy-duty Rotoblast barrels are described in a bulletin published by Pangborn Corp. The features of the blast cleaning process are illustrated with cut-away drawings, photos and sketches. Specifications and overall dimensions are also outlined. Illustrated case histories show how heavy-duty Rotoblast barrels have reduced costs substantially at many different installations. (Bulletin 705)

(5) Couplings

The Falk Corp. has published a bulletin on their complete line of torsionally resilient Steelflex couplings. New pages, additional coupling types, dimensions for larger sizes, and easier methods of selection are included. Falk's unique grid-groove coupling design protects connected machines against shock, vibration and misalinement is explained and illustrated. Charts and tables contain up-to-date engineering data. (Bulletin 4100)

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1010 EMPIRE BUILDING
PITTSBURGH 22, PA.

IRON & STEEL ENGINEER

Send The *free* Booklets Circled Below:

* MARCH, 1961

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56	57	58	59	60	61	62	63	64	65	66
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78										

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* INQUIRIES FOR ITEMS LISTED IN THIS ISSUE NOT VALID AFTER JULY 1, 1961

PUBLICATIONS CURRENTLY OFFERED by Iron and Steel Engineer Advertisers

ITEM	COMPANY	BULLETIN	DESCRIPTION
50	ALLEN-BRADLEY CO.	PUBLICATION 6090	Control units
51	AMERICAN-STANDARD INDUSTRIAL DIV.	BULLETIN A-1103	Bladed fans
52	BAILEY CO., WILLIAM M.	BULLETIN GB-100	Shut off valves
53	B-I-F INDUSTRIES		Coal blending systems
54	BLISS CO., E. W.	CATALOG 40B	Rolling mills
55	COLUMBUS McKINNON CHAIN DIV., COLUMBUS McKINNON CORP.	BULLETIN 100	Sling chains
56	CONE-DRIVE GEARS, DIV. OF MICHIGAN TOOL CO.	BULLETIN CD-218	Speed reducers
57	CUTLER-HAMMER, INC.	PUBLICATION E232	Mill brakes
58	DETRICK CO., M. H.	BULLETIN D-39	Refractory constructions
59	EATON MANUFACTURING CO., CLEVELAND WORM & GEAR DIV.	BULLETIN 405	Bronze gears
60	EDERER ENGINEERING CO.	BULLETIN CR-610	Industrial cranes
61	ELWELL-PARKER ELECTRIC CO., THE		Industrial trucks
62	EUCLID ELECTRIC & MFG. CO., THE	BULLETIN 4400	D-c speed controllers
63	FOXBORO CO., THE	BULLETIN 21-10	Electronic transmitters
64	GARLOCK INC.	CATALOG AD-181	Oil seals
65	HOMESTEAD VALVE MANUFACTURING CO.	REF. BOOK 39-1	Plug valves
66	HUNT VALVE CO., DIV. OF IBEC	BULLETIN 603	Air and hydraulic valves
67	LINK-BELT CO.	BOOK 2764	Coil handling equipment
68	McKAY MACHINE CO.	BULLETIN 107	Tube production equipment
69	OHIO ELECTRIC MFG. CO., THE	BULLETIN 112B	Magnet cranes
70	PENNSYLVANIA CRUSHER DIV., BATH IRON WORKS CORP.	BULLETIN 2013	Coal crackers
71	SPRAYING SYSTEMS CO.	BULLETIN 94	Descaling nozzles
72	SQUARE D CO., EC&M DIV.	BULLETIN 6132	Magnetic control for d-c cranes
73	TAYLOR CHAIN CO., S. G.	BULLETIN 14A	Alloy chains and slings
74	TAYLOR INSTRUMENT COS.	BULLETIN 98335	Electronic process controls
75	TAYLOR SONS CO., CHAS., THE	BULLETIN 507	Silica masonry
76	UNITED STATES STEEL CORP.		Forgings
77	WHITING CORP.	CATALOG FY-168	Electrode controls
78	YODER CO., THE		Slitting equipment

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78										

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The New Concept in Bearing Seals - Check these Advantages

1. Coolant kept out of bearings by non-rubbing, large capacity gutters. Oil contamination and roll end face wear eliminated.

2. Oil kept in by the **MORGOIL** flinger, now in molded synthetic rubber. A static spring loaded lip seal replaces sleeve packing.

3. A deep interlocking labyrinth with twin seals rubbing on a chrome plated surface seals in both directions for added protection.

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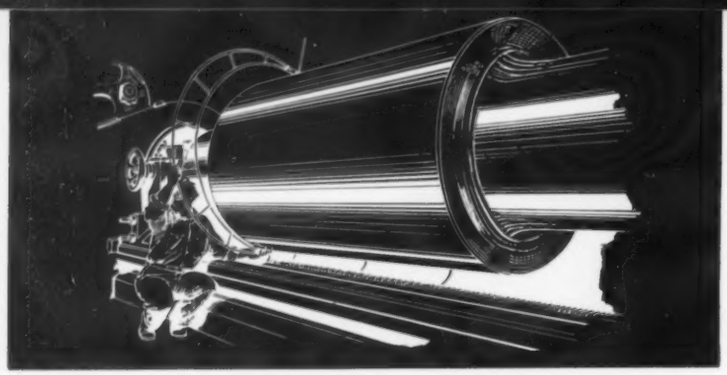
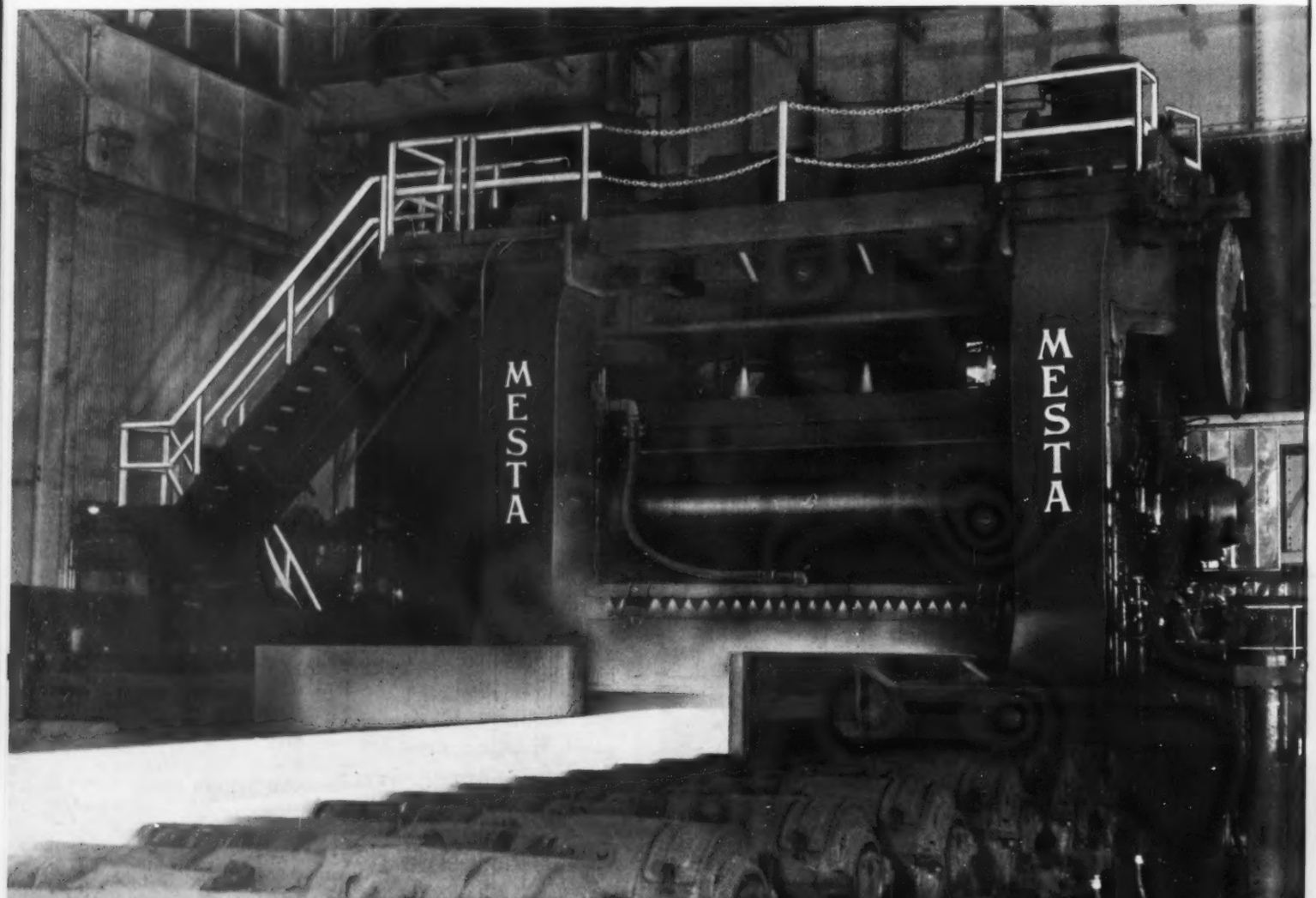


PLATE MILLS *designed and built by* MESTA



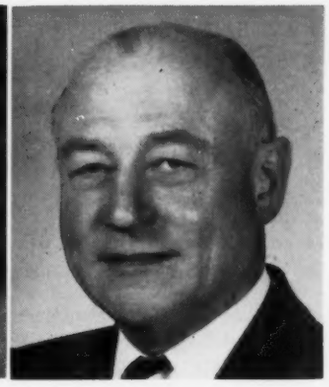
160" Four-High Reversing Plate Mill

MESTA *Machine Company*
Pittsburgh, Penna.

Personnel News...

Thomas E. Millsop has been elected chairman of the board and chief executive officer of National Steel Corp. He succeeds **George M. Humphrey** who has resigned as chairman but will continue to serve as a member of the board of directors and as chairman of the executive committee. **Paul Carnahan,** who has been chairman of the board of directors of Great Lakes Steel Corp., was elected president of National Steel Corp. Mr. Humphrey is a founder of National Steel Corp. and has been active in its affairs from the time of its organization in 1929. Mr. Millsop joined Weirton in 1927 as a salesman and was successively promoted to assistant sales manager, assistant to the president and vice president. In 1936, he was named president of the company and held that position until 1954 when he was elected president of National Steel Corp. Mr. Carnahan joined Great Lakes Steel Corp. in 1933 in the Blooming Mill Department. He advanced through supervisory ranks to superintendent of the Hot Strip Mill Department in 1941. He was appointed director of production in 1948. In 1953, he was elected vice president in charge of sales and in the following year became senior vice president and then president of the company. In 1958, Mr. Carnahan advanced from president to chairman of the board of Great Lakes Steel Corp.

T. E. MILLSOP



G. M. HUMPHREY

PAUL CARNAHAN

F. G. JAICKS

Frederick G. Jaicks has been named vice president of Inland Steel Co. He has been general manager of the company's Indiana Harbor works, and will continue in this capacity and also assume the responsibilities of **F. M. Rich,** vice president in charge of steel manufacturing, who has resigned. Mr. Jaicks has been with Inland since 1940, and has spent most of his career in the open hearth shops, beginning as a third helper. He moved up through plant supervision from practice foreman to general foreman, assistant superintendent and superintendent of open hearth departments to assistant general manager of primary production operations in 1956 and general manager of the plant in 1959.

Charles H. H. Weikel and **A. James Slater** have been elected directors of Bethlehem Steel Corp. Mr. Weikel is vice president, research, and Mr. Slater is assistant vice president, administration, Bethlehem Steel Co. Mr. Weikel entered the company's research activities in 1925. In 1931 he was placed in charge of industrial development in the Commercial Research Department, becoming manager of commercial research and industrial development in 1933. He was named assistant to president in 1957 and vice president last September.

C. H. H. WEIKEL

A. J. SLATER

Paul L. Tietjen has been elected vice president—traffic and transportation for Jones & Laughlin Steel Corp. Mr. Tietjen, who formerly was J&L's general manager of traffic and transportation, serves concurrently as president of the Union Dock Co. He joined J&L in 1941 at the Interstate Steamship Co. as marine superintendent. He was named marine manager for the company in 1942, and was promoted to manager of the Union Dock Co. in 1946. He became director of water transportation for J&L in Pittsburgh in 1948, and was named president of the Union Dock Co. in 1949. He was promoted to manager of the Traffic and Transportation Division in 1952, and was appointed general manager in 1958.

Thaddeus F. Bell recently was elected to the newly-created position of executive vice president and general

JEROME GRAHAM

I. D. CARSON

ROBERT PENOVICH

W. M. BLOOM

manager of Interlake Iron Corp. At the same time, the retirement of **John H. McDaniel,** vice president—operations, was announced. Both men have served with Interlake since 1924. Mr. Bell was also elected a director. He joined the company in 1946. He previously had been assistant to the president of Semet Solvay Co., now a division of Allied Chemical Corp. He served as secretary of Interlake until 1958, when he was elected vice president.

Jerome Graham has been named manager of the Commercial Research Department at Weirton Steel Co., division of National Steel Corp. He comes to Weirton from Great Lakes Steel Corp. where he has been employed as senior analyst in commercial research.

Irwin D. Carson has been appointed manager of product and market development at Weirton Steel Co., division of National Steel Corp. **John J. Kraina** was named assistant manager of the new department in which product development and marketing have been combined into a single responsibility. Mr. Carson comes to his new position from the company's Production Planning Department. Mr. Kraina is being transferred from the Sales Department. Mr. Carson joined Weirton in 1936 as an assistant to the metallurgist in the Steubenville plant, and a year later was transferred to the Strip Steel Department in the same capacity. In 1954, he was named assistant manager. In 1959, he was assigned to the Production Planning Department as assistant manager and held that position until his current appointment.

Robert Penovich has been named superintendent of Republic Steel Corp.'s Union Drawn Steel Division plant in Beaver Falls, Pa. Mr. Penovich, who has been assistant superintendent of Union Drawn's Massillon operations since February, 1960, succeeds **Aaron B. Seitz,** who will continue as a member of Union Drawn's metallurgical staff. Mr. Penovich has been with Union Drawn at the division's headquarters in Massillon since 1958. He joined Republic in 1949 as a mechanical engineer for Republic's chain plants in Cleveland and was named assistant superintendent of these plants in 1952 and superintendent in 1954. He was transferred to Union Drawn in 1958 when Republic sold its Cleveland chain operations.

William M. Bloom has been appointed chief fuel engineer, General Engineering Division, Allegheny Ludlum Steel Corp. Mr. Bloom was formerly senior fuel engineer in the General Engineering Division. He joined the Brackenridge works in 1951 as plant fuel engineer, and in 1955 was transferred to the corportation General Engineering Division. He was made senior fuel engineer in 1959.

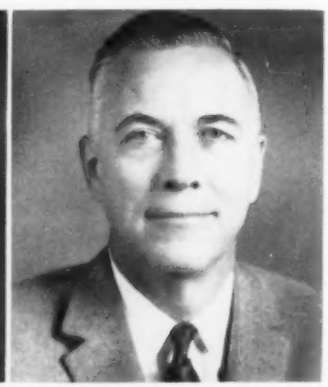
Emil A. Vierow has been appointed general superintendent, maintenance and utilities, Youngstown district, The Youngstown Sheet & Tube Co. He was previously assistant to the manager, Youngstown district. Mr. Vierow joined Youngstown Sheet & Tube in 1953 as superintendent, Fuel and Power Department. Previously he was associated with Jones & Laughlin Steel Corp., Alan Wood Steel Co. and American Steel and Wire Div., United States Steel Corp.

Dr. Theodore T. Magel has been appointed director of quality control, Allegheny Ludlum Steel Corp. He was formerly assistant to the vice president and technical director, joining Allegheny Ludlum in that capacity in 1957, after having served as a vice president of Nuclear Metals, Inc.

Earl A. Garber was elected chairman of the board of Harbison-Walker Refractories Co. At the same time **A. Brent Wilson** was named president, succeeding Mr. Garber, who will continue to be the chief executive officer of the company. Mr. Garber began work with Harbison-Walker as assistant foreman in the mines. He occupied various positions in the mines, in the Works Department, as foreman and plant superintendent, and as district superintendent. He was later manager of Northwest Magnesite Co., a subsidiary, of which he was named vice president and general manager in 1944. In 1947, Mr. Garber had become

E. A. GARBER

A. B. WILSON



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Micro-Cam Oil Valve. Oil flow control. Clog-proof, uniformly graduated, easy to read and set. Manual or automatic operation. Saves fuel, controls smoke and work spoilage. Thirteen sizes with capacities of 1.1 to 1,000 gallons of oil per hour depending on pressures available.

Type "S" Micro Oil Valve. Lighter construction lower cost. Precision control of oil to burner. Self cleaning, and triangular orifice prevent clogging and flame control problems found with needle valves. Linear adjustment settings easily read. Available with hand lever, head lever or for automatic control. Five sizes, capacities from 1.1 to 174 gallons per hour depending on pressures available.

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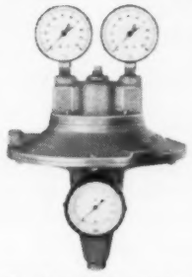

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Zero or Gas Air Ratio Regulators. Provide accurate control of gas flow for either low pressure proportioning mixer or nozzle mix type systems. Features—excellent balancing—soft seat—accurately machined valve system. Thirteen sizes available from ½ to 3 inches.

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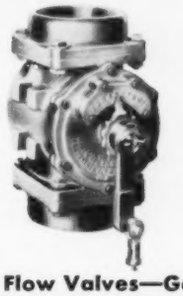

Adjustable Flow Valves—Gas or Air. Provide flexibility through adjustment of flow curve. These valves fulfill any exact metering requirements. Mounting bracket available to suit control motor for automatic systems. Fourteen sizes available from 1 to 6 inches. Also available in combination with adjustable port valves for precise control of gas to air ratios.

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vice president and general manager of Harbison-Walker and since 1948, has been president. Mr. Wilson joined the company in 1934 as an employee of Canadian Refractories Limited, a Harbison-Walker subsidiary. In 1948, he became general manager of Canadian Refractories. In 1950, he was transferred to Pittsburgh as assistant to the president of Harbison-Walker. He became a vice president of the parent company in 1955, and since 1958 has been executive vice president.

D. W. Kaufmann has been appointed product manager of stainless steels, Crucible Steel Co. of America. In this new capacity, Mr. Kaufmann will also be responsible for vacuum melted high temperature alloys, super alloys and titanium. Mr. Kaufmann joined Crucible in 1940. Beginning in the Harrison, N. J., research lab, he moved to the Sanderson-Halcomb works in Syracuse, N. Y., in 1941. He was moved to Crucible's Central Metallurgical Department in Pittsburgh, Pa., in 1950. During Crucible's joint ownership of Rem-Cru Titanium, Inc., Mr. Kaufmann served with that company from 1953 to 1957, advancing from assistant sales manager to manager of marketing. When Crucible acquired complete ownership of Rem-Cru Titanium, he was appointed product manager of the Titanium Division. In 1958, he assumed responsibility for sales of vacuum melted products, and in 1959, he became product manager of tool steels.

John T. Mayhew was promoted to assistant manager and **Benjamin W. Jones** to galvanize superintendent in the Sheet Mill Department of Weirton Steel Co., division of National Steel Corp. Mr. Mayhew, who succeeds the late **H. E. McDougle,** first worked for Weirton Steel in 1923. In 1931 he was transferred to the Strip Steel Department as pickler superintendent. Five years later he was named assistant to the galvanize superintendent in the Sheet Mill and in 1941 was promoted to galvanize superintendent, holding that position until his current appointment. Mr. Jones, who succeeds Mr. Mayhew as galvanize superintendent, began his employment with Weirton in 1925 as an assistant recorder in the blooming mill. In 1929, he became hot mill weighmaster in the sheet mill, four years later was named shearing and opening foreman, and in 1937 was promoted to turn foreman. In 1941, he was named galvanize weighmaster, became galvanize inspection foreman in 1945 and was named annealer in 1946. A year later he was promoted to superintendent of the sheet mill cleaning line, then in 1958 was named general foreman of the Galvanize Department, holding that position until his current appointment.

William L. Palmer has been named assistant superintendent of Republic Steel Corp.'s Union Drawn Steel Division plant in Massillon, Ohio. **T. E. (Ted) Kirch, Jr.,** succeeds him as division industrial engineer for Union Drawn. Mr. Palmer, who has been associated with Republic since 1945, has been Union Drawn's division industrial engineer since 1956. He joined the company as a time study engineer at the South Chicago plant. Mr. Kirch has been with Republic at the company's Port Henry Mining District, Mineville, N. Y., since 1948. He started as a student time study engineer, was named statistical standards engineer in 1951, and district industrial engineer two years later.

Robert W. Hanna, Jr., has been appointed manager of Link-Belt Co.'s Pittsburgh district office and warehouse. He succeeds **Otto W. Werner,** district manager for the past 15 years, who will devote his entire time to engineering contract sales. Mr. Hanna joined Link-Belt at its foundry in Philadelphia in 1941. He served in the Philadelphia district office and warehouse prior to his transfer to Pittsburgh, where he has been district engineer since 1948.

Steve Stasko has been appointed to the position of chief metallurgist of the Mackintosh-Hemphill Division, E. W. Bliss Co. He succeeds **Edward P. Sandbach** who was recently promoted to manager of manufacturing operations. He worked for Mesta Machine Co. until joining Mackintosh-Hemphill in 1956.

Francis C. Igoe was named superintendent of the Roll Department of Bethlehem Steel Co.'s Lackawanna N. Y., plant. He succeeds **Herbert A. Carter,** who retired January 31. Mr. Igoe joined the plant as a roll turner apprentice in 1922.

Henry A. Denny has been elected vice president and general manager of the Engineering and Construction Division, Koppers Co., Inc. **Chester E. Brown** was named vice president and general manager of the Tar Products Division, and **John H. Redmond,** vice president and marketing manager in the Tar Products Division. Mr. Denny, formerly assistant general manager of the Engineering and Construction Division, succeeds **Dr. Walter C. Rueckel,** who resigned December 30. Mr. Brown succeeds **F. L. Byrom,** who

J. T. MAYHEW

W. L. PALMER

R. W. HANNA, JR.

STEVE STASKO

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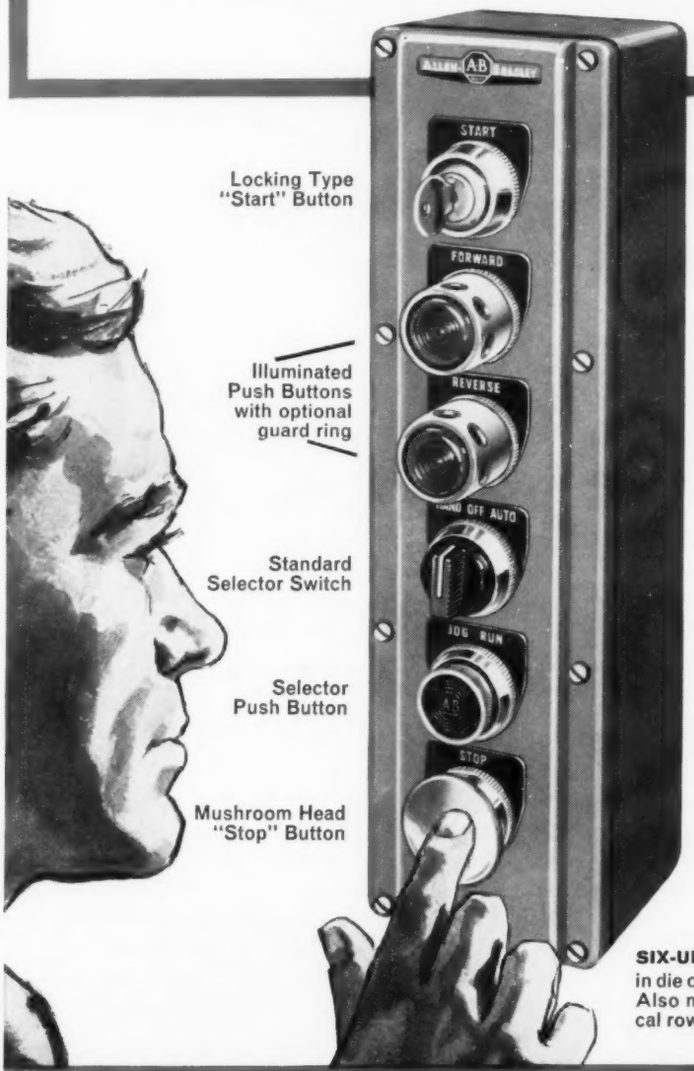

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push button, also made with extended head.

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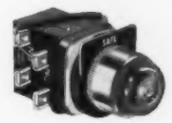

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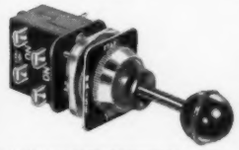
Six different color lenses available.



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Also furnished for 2-way operation.

PILOT LIGHT
Transformer or full voltage types.

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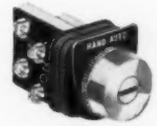
Has 2 N.O. or 2 N.C. sets of contacts.

PILOT LIGHT CLUSTER
Four lights of different colors in one unit.



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With coin slot operator. Other operators available.

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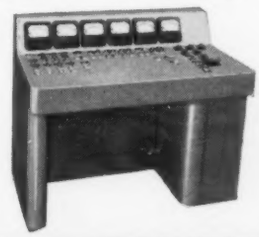
For plugging in work light or small tools.

SPECIAL CONTROL CONSOLES
can be furnished to meet your exact operating requirements.



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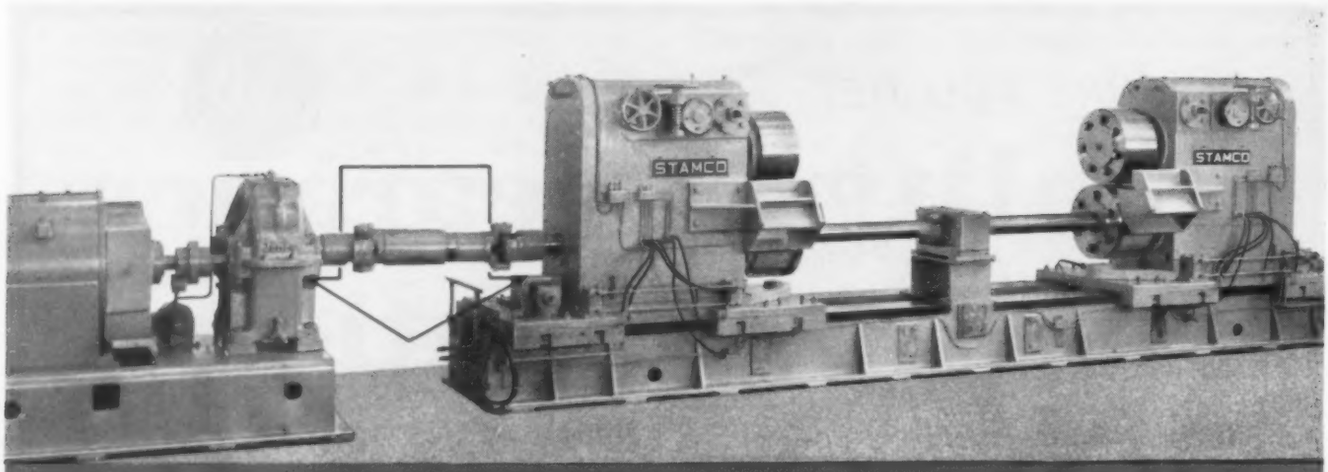
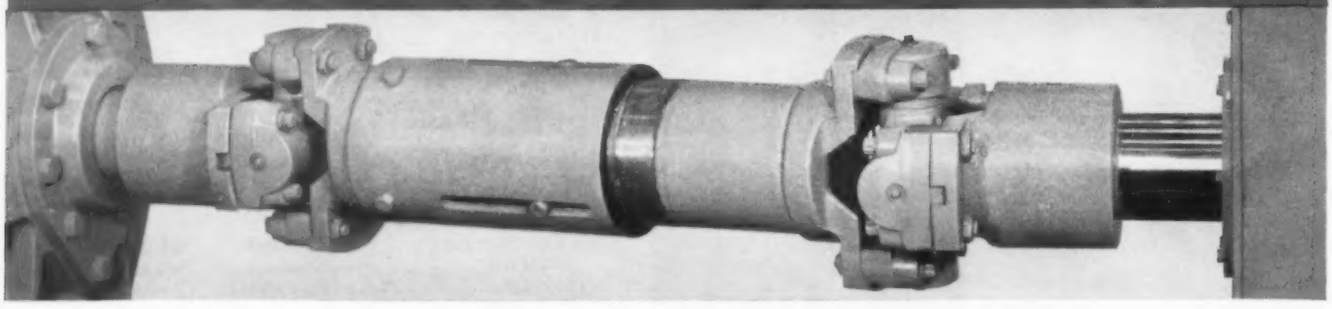


BLOOD BROTHERS "150WB" UNIVERSAL JOINT

MADE THIS STAMCO HOT MILL SIDE TRIMMER POSSIBLE



This Mammoth, custom-built Stamco machine weighs 85,000 pounds. Equipped with 24-inch diameter cutters and star type scrap choppers it can make two cuts of .300-inch in hot aluminum at the amazing rate of 1200 feet per minute!

During design stage, Stamco ran into a power transmission problem they had never encountered before. The coupling housing not only moved in and out for width but also had an angular movement of 3°. A coupling was needed to withstand heavy wear as well as the strain of the angular movement.

Stamco called in Rockwell-Standard engineers who recommended their largest universal joint, the Blood Brothers "150WB." The "150WB" easily handles 162,000 inch pounds of torque using a safety factor of 10 to 1 . . . in a swing diameter of only 13½ inches! A specially-designed "150WB" solved Stamco's problem, enabled them to satisfy their customer with a dependable, big-capacity unit.

Rockwell-Standard specialists can design and build *any* universal joint you need. Their wide experience and complete manufacturing facilities assure you of the most efficient performance at the most favorable price. Call or write today for further information.

Another Product of... **ROCKWELL-STANDARD CORPORATION**

ROCKWELL R STANDARD

Universal Joint Division, Allegan, Michigan

H. A. DENNY

M. D. MC CLAIN

was elected president on December 19. Mr. Redmond succeeds Mr. Brown in the Tar Products Division marketing post.

Mark D. McClain has been elected vice president of A. P. Green Fire Brick Co. Prior to his election, Mr. McClain served as assistant vice president and assistant to the general manager. He became associated with the company in 1950 when A. P. Green merged with the Valentine Fire Brick Co.

William F. Kast was named assistant chief engineer, Loftus Engineering Corp. He was formerly a fuel and combustion engineer with United States Steel Corp.

Obituaries

Leroy R. Brooks, president, The Tool Steel Gear and Pinion Co., died January 16.

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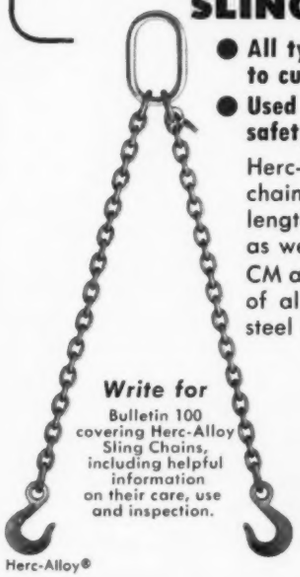
CM also produces welded chain of all types including stainless steel and bronze.



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in hardened stainless steel

in stainless steel with tungsten carbide orifice tips

- compact — modern design . . . only ½ to ⅓ the size of old nozzle types
- advanced hydraulic design — gives extremely sharp, hard hitting FLAT SPRAY pattern
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Here are spray nozzles with sharp, high-impact flat spray patterns to materially improve your descaling operations. They're small in size for easier installation and better performance. The unusually large orifices go far in solving clogging problems. Made in all capacities in hardened stainless steel for high resistance to sand and silt. And for maximum possible abrasion resistance, they're also made with Tungsten Carbide orifice inserts. Just write . . . we'll be happy to send you complete Descaling Spray Nozzle information.

HEAVY DUTY LINE STRAINERS

Spraying Systems now offers line strainers in a full range of sizes . . . with threaded connections up to 4" N.P.T. size . . . and flanged connections in 3", 4" and 6" pipe size. Designed for operation at pressures up to 125 psi. Unusually large screen areas for high volume capacity. Heavy duty, reinforced screens. Easily flush-cleaned through bottom plug or drain cock. Write for Bulletin 94.

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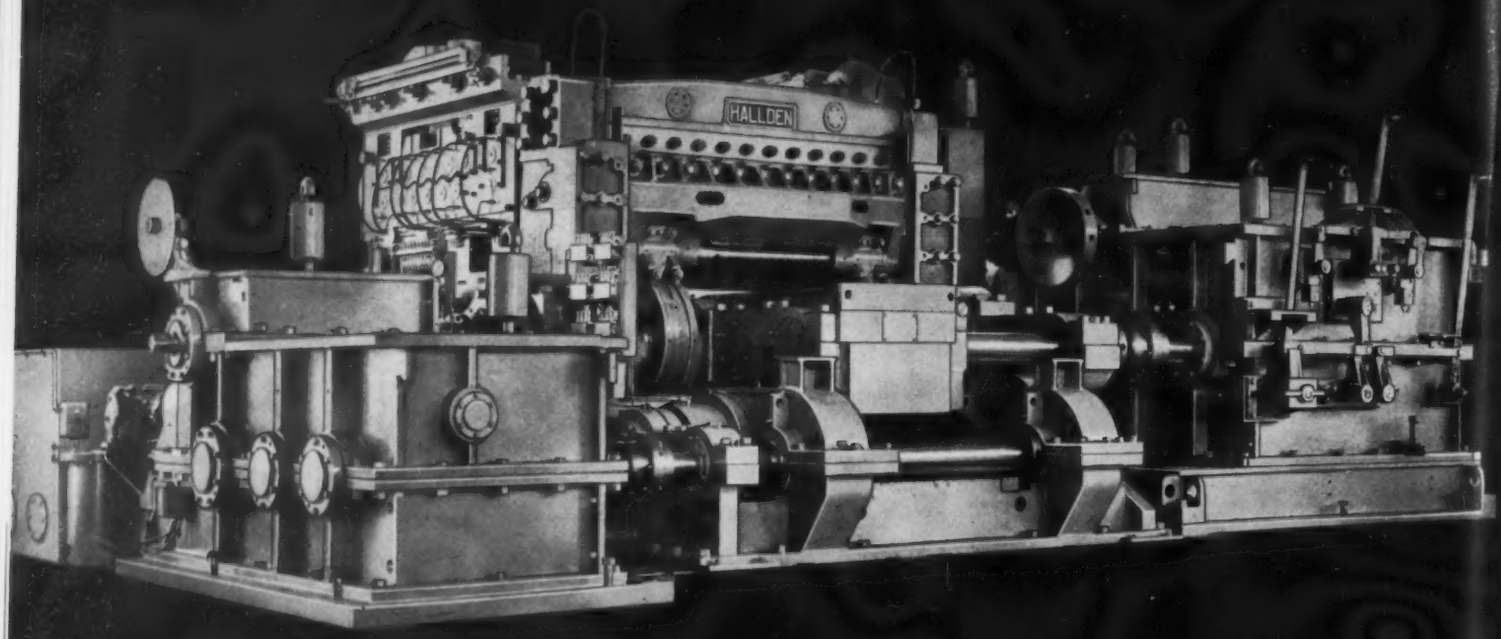

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Associates: The W. H. A. Robertson & Co., Ltd., Bedford, England

Chemico P-A Venturi Gas Washer Chosen By Kaiser For No. 1 Blast Furnace

The venturi washer at the Kaiser plant is just one of fifty CHEMICO venturi washers specified and installed by major steel producers for cleaning blast furnace gas. Performance figures and maintenance records of blast furnaces using CHEMICO venturi washers indicate the following:

1 The CHEMICO venturi washer is the most efficient wet washer in operation anywhere. Where higher top pressures are available, for example, gas can be cleaned to less than 0.003 Gr/Scf, eliminating the need for secondary precipitators.

2 CHEMICO venturi washers require virtually no maintenance for an entire furnace campaign.

3 Capital and installation costs are less than other primary or secondary gas cleaners.

4 Minimum space is required. Generally, the CHEMICO venturi washer is set into space formerly occupied by gas mains.

5 Water requirements are about a third of other wet washers.

6 Latest designs incorporate adjustable controls which enable maximum gas cleaning efficiency to be maintained regardless of wind rate.

If you are considering the installation of gas cleaning equipment on a blast furnace, a CHEMICO representative would be pleased to show you the kind of top-performance job you can expect from a Venturi washer. CHEMICO handles the complete job, **Planning, Design, Engineering, Erection and Start-up.**

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
GAS SCRUBBER DIVISION
320 Park Avenue, New York 20, New York

Sales Representatives in:
Ferndale, Mich. • Chicago, Ill. • Los Angeles, Calif. • Houston, Tex. • Bartow, Fla. • Birmingham, Ala. • Millersville, Pa.

What good steel rolls are made of

Proper ingredients, modern facilities, experienced people and quality control . . . this is what steel rolls are made of at National Roll. They start with the careful selection of the correct steel analysis to suit your application. Then, men like Works Manager Jack Russell, pictured above, carefully control the quality of your rolls from electric furnace melt to turning and grinding. Why not see for yourself what good rolls are made of at National—whether steel, iron or nodular iron. A look at our facilities and a talk with our people will show you why . . . NATIONAL'S THE GROWING NAME IN ROLLS.

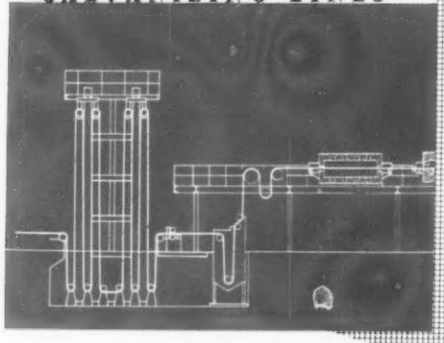
NATIONAL ROLL & FOUNDRY DIVISION
GENERAL STEEL CASTINGS CORPORATION, Avonmore, Pennsylvania
General Steel Castings Corporation. General Offices: Granite City, Ill. Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.
Subsidiary: St. Louis Car Company, St. Louis, Mo.

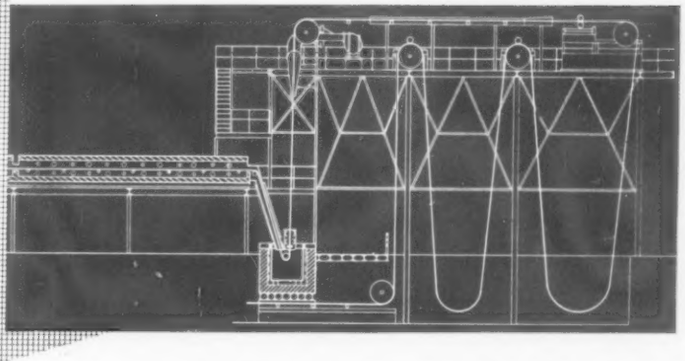
FURNACES AND HEATING EQUIPMENT

General view of two galvanizing lines constructed for S.A. Phenix Works at Flemalle-Haute (Belgium).

HEURTEY

HEURTEY - SENDZIMIR CONTINUOUS WIDE STRIP GALVANIZING LINES





world references

PARIS - LIEGE - LYONS - MADRID - MILAN - VÄSTERÄS

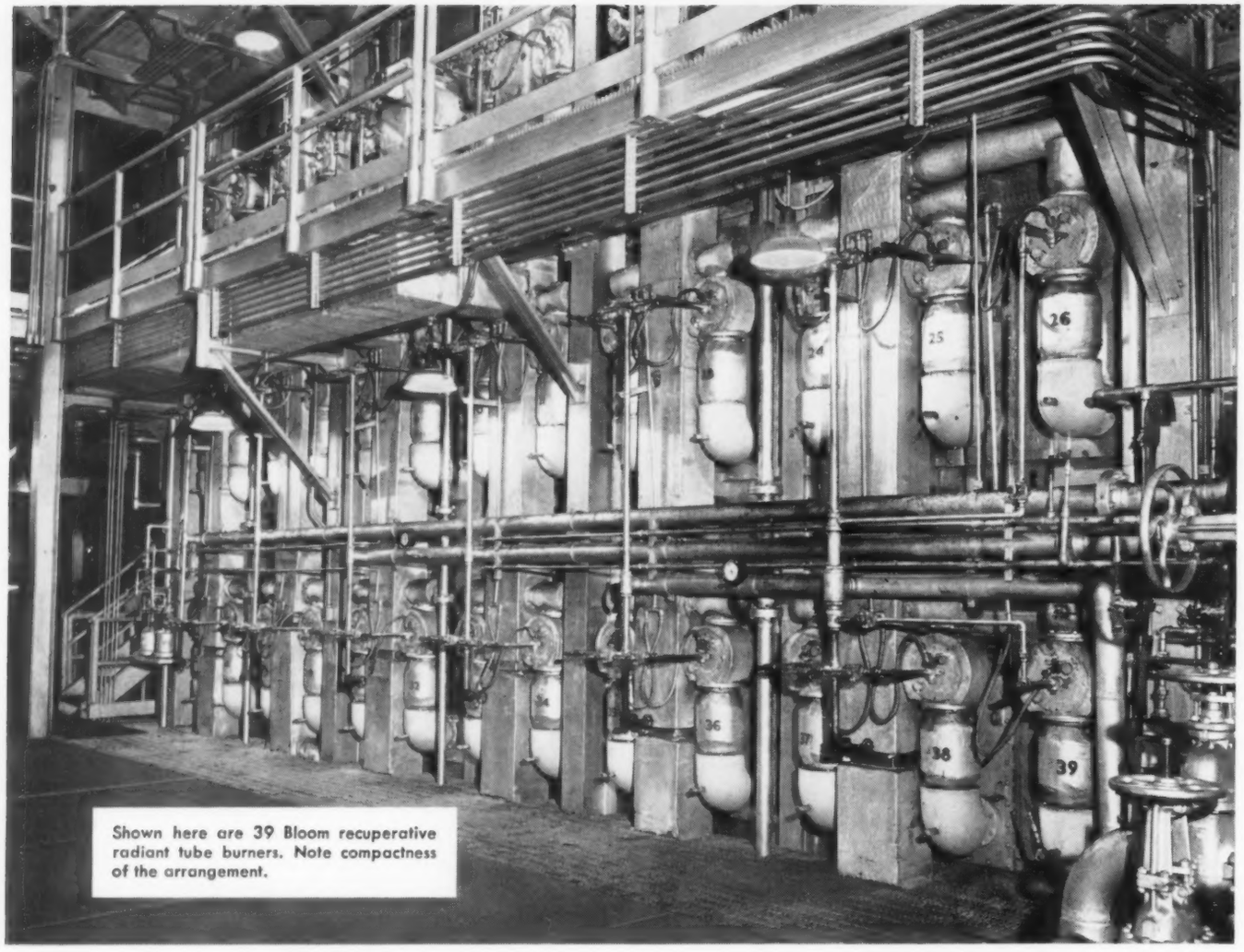
HEURTEY constructed in FRANCE, BELGIUM and LUXEMBURG a large number of SENDZIMIR lines either as straight or as recuperative furnaces for a range of production of 3 - 10 t/h. Identical lines can also be designed for a production up to 20 t/h.

HEURTEY

38, AVENUE GEORGES MANDEL - PARIS

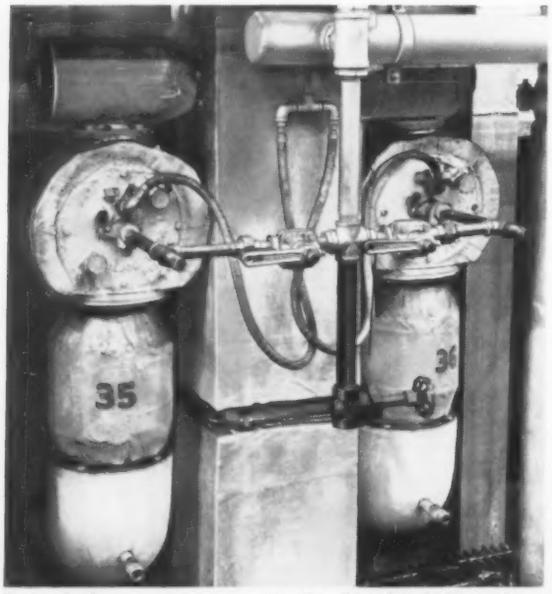
KLÉ. 48-00 +

A. 187 ang. - PUB JMRabec



Shown here are 39 Bloom recuperative radiant tube burners. Note compactness of the arrangement.

208 BLOOM BURNERS
heat Weirton's giant furnace

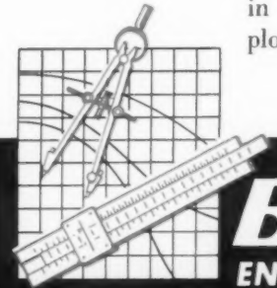


Burner and recuperator are unitized and insulated. Air preheat is 700°F. Continuous-burning, removable pilots are seen above the gas inlets.

Heat to anneal tinplate in the new continuous furnace at Weirton Steel Company is furnished by 208 Bloom Recuperative Radiant Tube burners. The Bloom burners have operated trouble-free for more than a year under severe fuel conditions.

Bloom Radiant Tube burners are designed for operation with coke oven gas, natural gas, butane or oil. Easily-lighted, stable pilots are provided. Alloy construction prevents warping. Proven burner design provides uniformly-heated, clean radiant tubes, thus assuring maximum tube life.

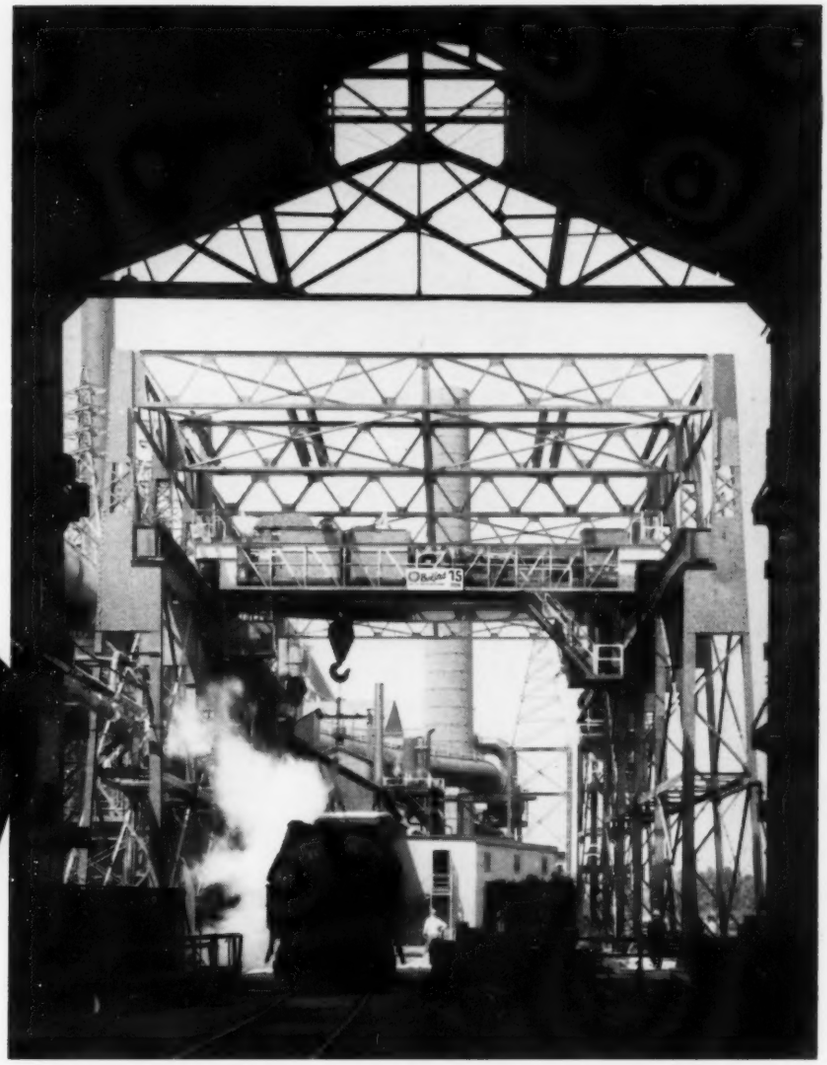
Bloom engineers will gladly cooperate in designing combustion systems employing these or other Bloom burners.



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

IN STEEL MILLS

WEIGHT LIFTING MADE EASY



Yuba designs and builds all types of custom steel cranes with lifting capacities of 5 to 1000 tons, for indoor or outdoor service.

Yuba-Bedford Steel Mill Cranes are working to plant capacity —24 hours a day —year after year

Two generations of steel makers have operated Bedford Cranes in mills from Pennsylvania to Peru. These are mills where the handling jobs are tough—where cranes work shift after shift under all conditions —and where there's time for only routine maintenance.

Hundreds of Bedford Cranes have been manufactured for leading steel producers...cranes that are specially designed and custom-built by Yuba to the tough requirements of the steel industry. Big lifting problems are made easy on every shift—for years!

Yuba designs, builds and erects all types of cranes including bridge, unloading and material handling, gantry and semi-gantry, floating and jib cranes. Also derricks, hoists and launching towers for defense ordnance.

YUBA

specialists in steel mill cranes and custom cranes of all types

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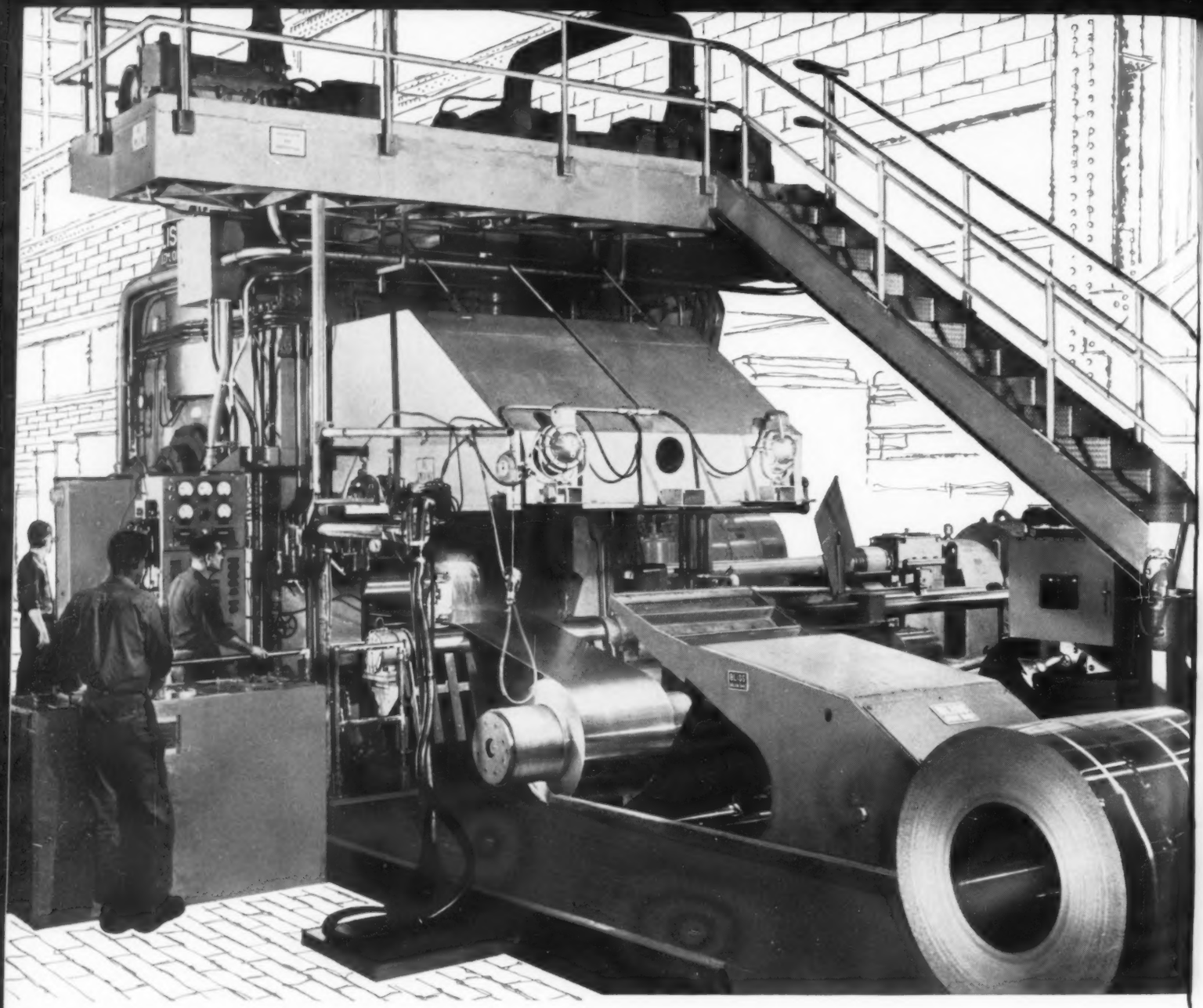


SAYS ANACONDA ALUMINUM:

One good mill deserves another

Picking a Bliss rolling mill for their new aluminum plant in Terre Haute, Indiana, was easy for Anaconda Aluminum Company: for years these mills have had an outstanding performance record in the aluminum industry.

A new Bliss 14″ x 49″ x 66″ four-high one way cold mill capable of speeds up to 1200 fpm, it is equipped with the auxiliaries necessary to produce aluminum coiled sheet in 60″ widths and at specified thicknesses as fine as .006″. Bliss supplied the mill with complete entry and delivery equipment, including entry coil conveyor, coil lowering device, coil preparation station, mandrel-type payoff reel, coil buggy, and tension reel and coil buggy.

Anaconda's operation brought the "best" out of the Bliss mill as plant management found its production record to be excellent and economical, too. This installation is just one more example of the acceptance of Bliss rolling mill equipment. For others, in both ferrous and non-ferrous operations, write us today for a copy of our 84-page Rolling Mill Brochure, Catalog 40B.

BLISS
SINCE 1857

Bliss is more than a name . . . it's a guarantee

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Rolling Mills • Mill Auxiliaries • Amerigear/Bliss Flexible Spindles

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

Equipment News...

SPEED REDUCERS

△ Cleveland Worm & Gear Division, Eaton Manufacturing Co., announces the addition of vertical units to its new line of fan-cooled worm gear speed reducers. Nine sizes, ranging from 3-in. to 12-in. center distances, are available. Ratios extend from $4\frac{1}{7}$:1 to 95:1; ratings are fractional to 175 hp.

The new units incorporate the same features—such as fan cooling, specially hardened worms and centrifugally cast gears—that were originally designed in the first reducers of the fan-cooled line. They have a much higher average rating than comparable reducers not having an auxiliary means of cooling.

All of the new vertical units have one-piece finned housings for maximum strength and heat dissipation. Gear shaft bearings are grease lubricated, with two fittings for each bearing. One fitting is used as indicator; grease flowing from it shows that the bearing is fully packed. Oil seepage, often a problem in reducers with downward shaft extensions, has been prevented by incorporating a dry well around the output shaft and extending above the oil level.

STATIC FAULT FINDER

△ The Clark Controller Co. has announced a new device for automatically indicating the location of faults and malfunctions in electrical control equipment. Known as the Bulletin 5205 static fault finder, the design features static magnetic type switching and memory type operation. Low-voltage incandescent lamps indicate faults.

Because of the memory feature, each lamp remains lighted until manually reset, even though the fault has been cleared. The unit is ideally suited for detecting open contacts in protective or emergency stop circuits.

Designed for operation with 115 to 300-volt d-c or 120-volt, 60-cycle control circuits, each fault finder unit can monitor one to six individual devices. The all-static design is composed of six full-wave self-saturating magnetic amplifiers—one for each control circuit device to be monitored. If more than six circuits are required, additional units can be used.

Input power for the static fault finder is 115 volts, 60 cycle. It is designed to operate within a ±15 per cent line variation. A power transformer isolates the input supply from all other circuits. In addition, isolation exists between the control circuit and the indicating light system.

Static fault finders are available with or without enclosures. The open type unit is suitable for flush mounting only. NEMA Type 1 general purpose enclosures are available.

ALARM UNIT

△ A compact electronic watchdog, designed to oversee as many as 200 high or low temperatures, pressures, flows, levels or contact closures at the rate of five points per second, has been introduced by Hagan Chemicals & Controls, Inc.

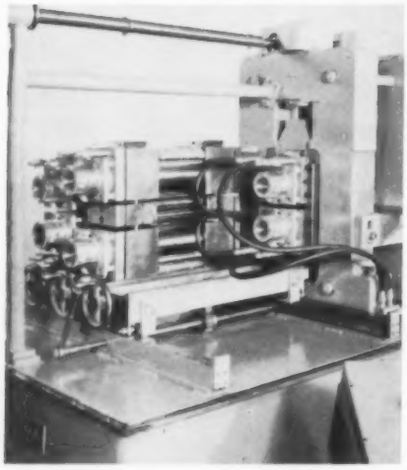
Designed to monitor any input that can be represented by a d-c voltage as low as 10 millivolts full scale, the Hagen AIM (Alarm Indicating Monitor) is applicable to iron and steel plants, petroleum refineries, petro-chemical complexes, electric generation stations, cold storage plants and other industrial processes.

Display lights on the AIM's control panel indicate to operators that out-of-limits conditions are occurring and indicate the point's

CRUCIBLE ADDS BULK GREASE HANDLING SYSTEM

Application of a new trend in delivering grease is illustrated by the procedure set up by Crucible Steel Co. of America and the Humble Oil & Refining Co. Some 20,000 lb of grease in bulk is shown being delivered to the Midland plant to be used in the new 54-in. semi-continuous hot strip mill. The new bulk grease handling installation is expected to save at least 40 per cent over the conventional methods. The bulk grease truck has three canisters, each designed to hold 10,500 lb or 31,500 lb of grease. Each canister is emptied separately allowing the handling of three greases without mixing. The grease supplier will deliver from their plant directly to the consumer's storage tank.

NEWS FROM
LOMA



This heavy-duty, high-precision 2-high/4-high Combination Rolling Mill was recently installed at the new Fuels Technology Center of the Argonne National Laboratory. The outstanding feature of the new machine is its complete enclosure in a controlled atmosphere glovebox to allow the processing of alpha-active, pyrophoric materials, such as plutonium.

To facilitate remote control operation within the glovebox enclosure, the mill is equipped with a mechanized roll changing device comprising a roll storage car, three slideways to carry three roll assemblies, quick-disconnect screwdowns and universal spindle supports. The entire roll assemblies are readily moved into or out of the mill by turning a handwheel and are cross-transferred by moving the car along the face of the mill. Thus, complete roll changes can be performed in a few minutes without undue effort.

The new LOMA rolling mill may be operated in either a 6 in. x 8 in. 2-high set-up or a 1½ in. & 6 in. x 8 in. 4-high set-up. The 2-high arrangement is used for either hot or cold breakdown rolling of plate and sheet, and grooved rolls are also available to process rounds from 1 in. to ¼ in. diameter. In the 4-high set-up strip is cold finish rolled to gauges as thin as .002 in.

The mill is furnished with high-strength steel housings, twin-handwheel wormdrive screwdowns, universal joint spindles, herringbone gearing, and a 15 h.p. reversing variable-speed drive. The roll necks are mounted in super-precision needle roller bearings having a total separating force capacity of 175,000 lb. The bearings are continuously lubricated by an oil circulating system.

Special cartridge heating elements are mounted in the rolls to prevent undue chilling of the materials being hot worked. The heating elements are fed with current through slip rings and brushes mounted at the outboard side of the mill.

LOMA
MACHINE MFG. CO., INC.
114 East 32nd Street
New York 16, N. Y.

name and number. When an alarm occurs, a warning horn also sounds. The horn may be silenced by an acknowledgment button, but the alarm light will remain lit until the out-of-limits condition is rectified. For example, if an operator wanted notice whenever a temperature exceeded a limit of 240 to 250 F, the AIM would alarm whenever the temperature fell a fraction of a degree below 240 F or rose a fraction of a degree above 250 F.

Limits are individually set by inserting pins in a pinboard. Alarm accuracy is ±0.1 per cent full scale. Detection of an out-of-limits signal is obtained by comparing the voltage from the alarm set point pinboard to the voltage from the AIM's d-c amplifier. If the amplifier voltage is higher or lower than the set point reference voltage, an alarm comparator, which has a resolution to one point in 10,000 full scale, produces an alarm pulse. This pulse closes the memory relay for that particular point, and energizes both the alarm light and the audible warning horn.

Thus, all alarm functions are combined in one compact instrument. The readout and alarm panel for one 200-point AIM will fit into a panel area only 19 x 47½ in.

Only 12 different basic printed circuit logic boards are used in a typical system. Combinations of these boards provide for input sequencing, time delay for amplifier balancing, selecting alarm values, addressing alarm lights, determining alarm conditions and addressing input matrix for readout.

Manual readout of any point, accurate to ±1 per cent full scale of the increment selected, is available continuously. Once, each 2-second period, the system selects the point addressed for manual readout, and in 200 milliseconds applies its signal to the readout meter. The meter holds this reading until two seconds later when the next reading is taken. For example, to obtain information on point 155, the operator switches the three 10-position selection knobs to 155, and the meter will indicate the reading of this variable. During the 2-second hold time the systems scans 10 other inputs.

To provide visual check of the present location of the scanning

RUGGED
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OHIO Magnets
Rugged, powerful and cool-operating for bigger all-day loads. Brawny and tough to stand the gaff in roughest service. Specify Ohio Magnets. There's a type to solve every magnetic handling problem.
Contact your nearest Ohio representative for magnetic materials handling recommendations, or write for Bulletin 112B.
THE OHIO ELECTRIC MFG. CO.
5400 Dunham Road
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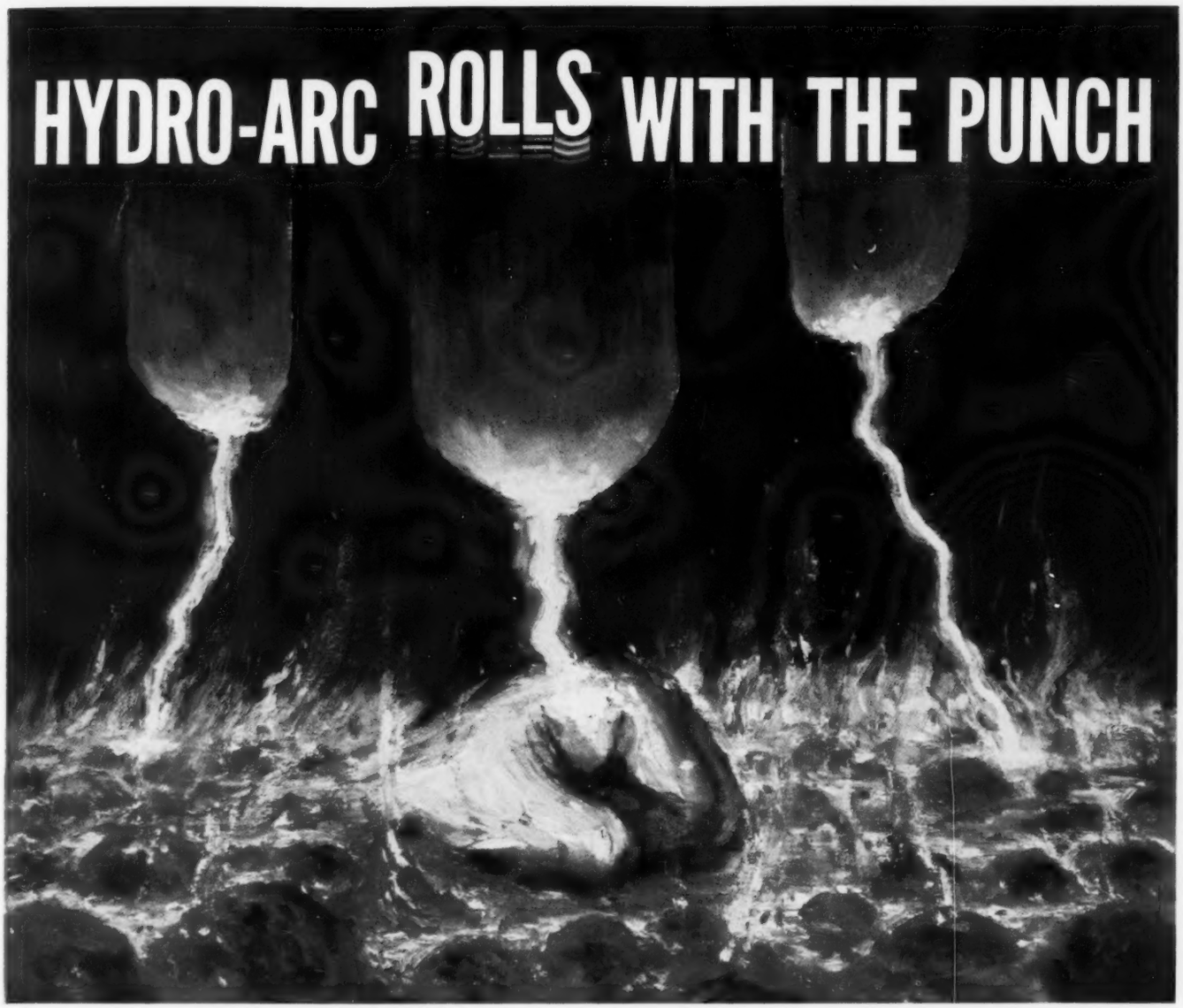
Subsidiary of HOWELL ELECTRIC MOTORS COMPANY

HYDRO-ARC ROLLS WITH THE PUNCH



FASTER THAN ANY OTHER FURNACE!

Electrodes must literally "roll with the punch" to maintain the precise arc gap for peak heat intensity in relation to surface of melt. This means *instantaneous* adjustment to constant surface roiling caused by shifting charge or escaping vapors.

HYDRO-ARC alone offers electrode controls developed specifically and exclusively for electric furnace operation. Not one but two *non-reversing* electrode motors are used to operate this hydraulic control. An exclusive air counterbalance further speeds reaction. The movement of HYDRO-ARC electrodes is *instantly* and *automatically* monitored by the very energy of the arc itself! You get faster, cleaner melts, lower costs, and virtually no electrode breakage.

Learn how Hydro-Arc can lower *your* melting and processing costs while increasing production and quality. See your Whiting Furnace Engineer, or write for Hydro-Arc Catalog FY-168. *Whiting Corporation, 15655 Lathrop Avenue, Harvey, Illinois. In Canada: Whiting Corporation (Canada) Ltd., 350 Alexander Street, Welland, Ontario, Canada.*

90 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

ELECTRIC-ARC FURNACE

WHITING

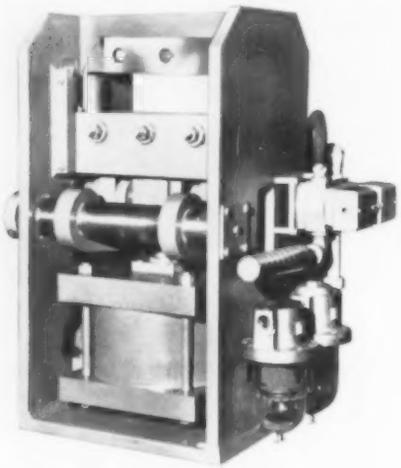
MANUFACTURERS OF CRANES: TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES;® FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

address, and to indicate that continuous scanning is in operation, point identification is continuously displayed in digital form in lighted numbers on the control panel.

Simple self-checking devices are incorporated into the AIM that provide excellent maintenance and verification checks. A three-position switch is provided to run a complete alarm circuit check that will verify operation of the detecting amplifier, alarm circuit and all indicating lights. Another switch is provided that will introduce a continuity check of all input circuits and input selection relays. Each of these checks requires approximately 30 sec and can be done as frequently as the operator feels is necessary.

SHEARS

△ Designed for use in steel processing lines or coil build-up lines are a new group of shears introduced by Curry Air Shear Corp. The Type CU-12-12 shears are recommended for use in cropping ends of coils,



cutting out rejected parts of coils or cutting-to-length.

Made in widths from 24 in. to 84 in., these shears are made for operation either by hydraulic pressure or compressed air. They can be furnished in capacities for cutting up to $\frac{3}{16}$ x 96-in. mild steel. The units were designed to occupy a minimum of space in order to fit into processing lines without disrupting other machinery.

NEW ALUMINUM COATING

△ Rust-Oleum 1030 green aluminum, recently announced by Rust-Oleum Corp., is specially formulated to produce a tough, durable, attractive finish for widespread use by industries and municipalities. It incorporates the same high quality ingredients as other Rust-Oleum exclusive formulations to resist moisture, sun, fumes and weathering.

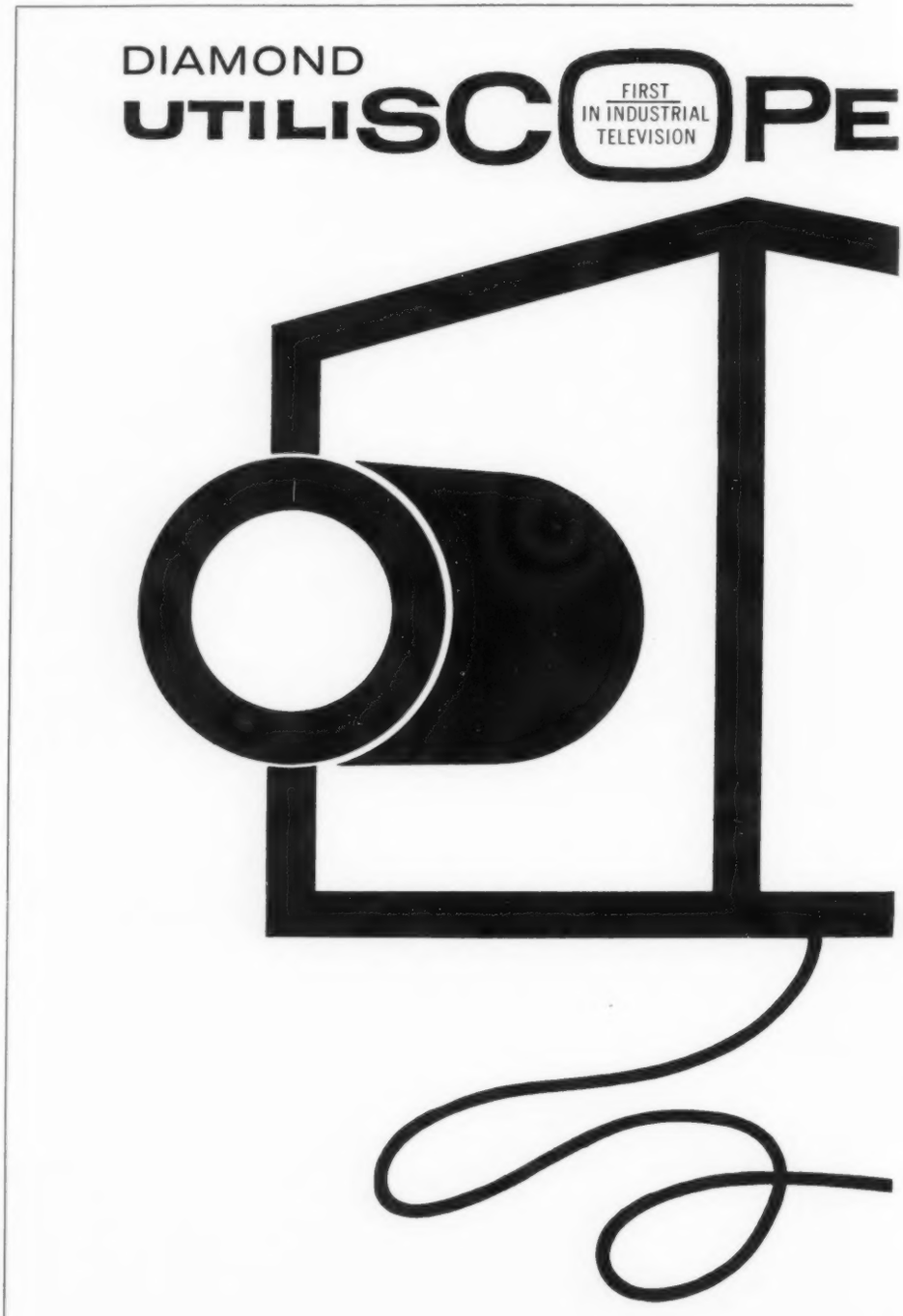
Green aluminum is ideally used as a top coat on exterior and interior surfaces; with its pleasing color it is of particular interest for use on tanks, structural steel, metal sash, piping, wire fences, metal roofs and buildings.

Green aluminum may be used as the top coat over the recommended Rust-Oleum primer on sound rusted surfaces, clean metal, previously painted metal or wood, and new, bare or unpainted wood. It is available in five gallon, one gallon and quart containers.

CIRCUIT BREAKERS

△ A new 800-amp molded case circuit breaker—which provides one third saving in panel space—has been announced by I-T-E Circuit Breaker Co.

Development of this unit marks final step in I-T-E's program to reduce size in its molded case



breaker line, without any reduction in quality or performance.

The breaker, designated KM frame, is smaller than its LM predecessor by one frame size, and provides exactly the same electrical features and ratings of LM units.

The new KM breaker is available in two and three-pole construction in current ratings of 125 through 800 amp, for 600 volts a-c and 250 volts d-c.

Height of the KM is 15½ in.—6½ in. less than that of the LM. Depth has been reduced from 5¾ in. for the LM to 4 1/16 for the KM. Width remains unchanged.

The smaller size of the new KM breakers permits more units to be mounted in a standard switchboard, while distribution and power panelboards can be built shallower because of unit's reduced depth. Easier handling and installation also result from breaker's reduced size and weight.

Standard features on the KM unit include enclosed terminals and front adjustable instantaneous trips. Pressure wire connectors are available for front connection of the breakers in panelboards, individual enclosures and control cabinets. Rear connecting studs and plug-in connector assemblies are available for switchboard mounting.

Special features such as shunt trips, auxiliary and alarm switches and undervoltage trip devices can be furnished for internal mounting.

SPRAY NOZZLES

△ Spraying Systems Co. has announced that its slope-bottom Whirl-Jet spray nozzles are now available in larger capacity ½ in. inlet sizes. These hollow-cone vortex-chamber design spray nozzles provide unusual resistance to the erosive effects of vortex flow.

Experience has proved that these slope-bottom design WhirlJets last many times longer than standard vortex-chamber design nozzles. With these larger capacity ½ in. inlet nozzles, slope-bottom WhirlJets are now available in a large choice of capacities, ranging from 0.08 to 19.0 gpm.

MOTOR INSULATION

△ The introduction of "Capsular" insulation system for encapsulated random wound a-c induction motors has recently been announced by The Louis Allis Co.

The new encapsulated motors offer added protection against moisture, chemicals, oils and abrasive contaminants, providing longer life for open motors used in adverse environmental atmospheres.

The smoothly encapsulated, void-free, conventionally wound stators feature heat-resistant, plastic-resin that completely seal end coils and fills spaces between wires in the stator slots with a moisture-proof, chemical - resistant, protective sheath.

The encapsulating material has high dielectric strength and exceptional thermal endurance, permitting operation over wide extremes and sudden changes of temperature without cracking, crazing, or breaking of the bond between the plastic compound and stator laminations or windings. High resiliency of the material allows it to easily withstand the effects of air-borne contaminants drawn into the motor by the ventilating air stream.

Capsularn isulation system can be supplied on open, drip-proof

"TAILORED" FOR THE TOUGH TESTS OF IRON AND STEEL

Closed-circuit television for iron and steel mill applications takes a "toughness" you'll find only in Diamond Utiliscope. Despite extreme heat, magnetic dust, vibrations or shock, Utiliscope provides reliable and accurate viewing of blast furnace and coke oven interiors plus a whole range of rolling and finishing operations . . . all from one safe, central control point. Regardless of *your* application, there's a Diamond Utiliscope System to help you save money by improving operations. The coupon below will bring complete information.

Diamond® Electronics

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Diamond Electronics • Lancaster, Ohio

Please send complete information on how Diamond Utiliscope can help reduce operating costs and improve operations.

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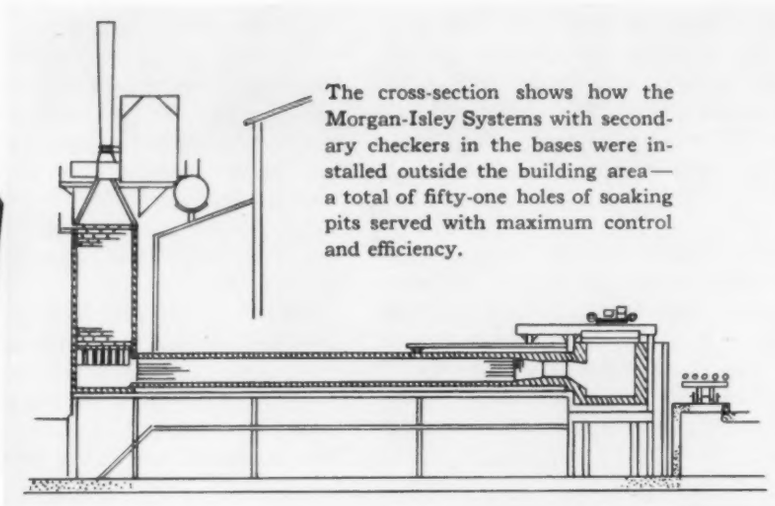
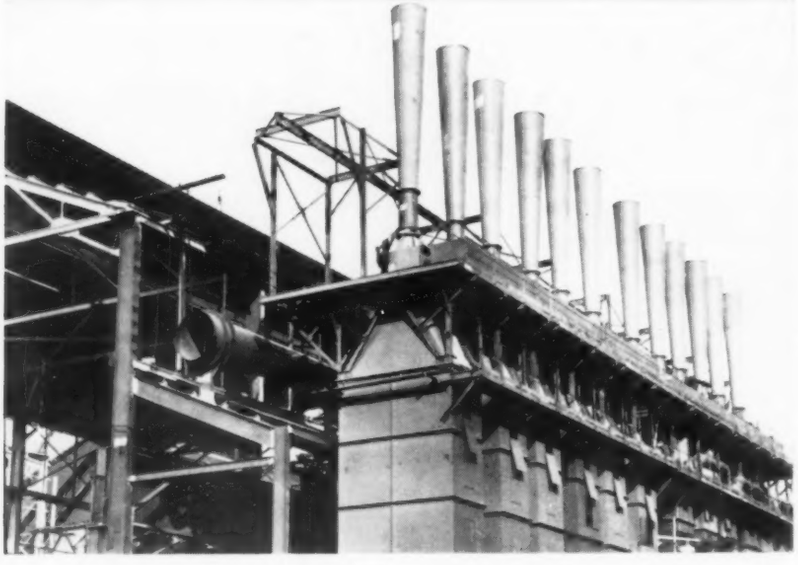
INCREASE SOAKING PIT CAPACITY *within limited space*



The cross-section shows how the Morgan-Isley Systems with secondary checkers in the bases were installed outside the building area—a total of fifty-one holes of soaking pits served with maximum control and efficiency.



WITH MORGAN-ISLEY SYSTEMS

You can obtain preheat temperatures as high as 2200° F. with the Morgan-Isley System using secondary checkers in the bases of the ejectors. In the installation illustrated above, straight blast furnace gas is the fuel used with excellent results. The flexible design of the Morgan-Isley System allows it to be located clear of valuable heating areas.

C-1

MORGAN WORCESTER

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

ROLLING MILLS · MORGOIL BEARINGS · WIRE DRAWING MACHINES · COMBUSTION CONTROLS

motors, 445U frame sizes and smaller—600 volts, and below, including special electrical and mechanical features.

BALL VALVES

△ A new line of ball valves, in bronze, steel and type 316 stainless steel and in a range of sizes from ½ in. to 2 in., has been perfected by Crane Co.

Designed for service in a wide range of industrial applications, the valves are rated for pressures from vacuum to 800 psi, and for temperatures from minus 40 to 400 F. They are two-directional, with low operating torque and precision-machined chrome-plated ball. The seats are Teflon with controlled preloading to maintain bottle-tight shutoff even in air and gas service, or when used to control volatile fluids.

A unique design feature of the new line of ball valves is the tapered cartridge which contains the entire seating assembly and which may be removed easily while the valve body remains in the line. Removal of a single retainer nut, requiring no special tools, permits the cartridge to be ejected from the bottom of the valve body, and it can then be cleaned or dismantled quickly. Reassembly of the cartridge is simple, with all parts marked to eliminate any possibility of error. Full interchangeability of parts makes maintenance even simpler, and there are no shims, springs or other special adaptations required.

When the cartridge is replaced in the body, the tapered design positions it automatically, and take-up on the retaining nut results in proper sealing contact. In addition, O-ring seals on both stem and cartridge ensure proper closure, and a Teflon thrust washer between the stem and stem retainer absorbs any shock resulting from line pressure, preventing displacement of the ball.

The handles of the new valves require only a quarter of a turn from full open to full closed, and are plastic-sheathed for insulation. The bright orange sheathes also serve to flag valve position, since the handle is parallel to the pipe line when the valve is open, and stands out perpendicularly when it is closed.

UNCOILER

△ The Steel Equipment Co. has announced a new uncoiler that can provide precisely controlled tension on light-gage slitting or processing lines. Normally, coil steel being slit into narrower coils is pulled through the slitter by the recoiler. However, with light-gage stock, pull-through slitting can be improved. Driven slitting is then employed, but the uncoiler must supply carefully controlled back tension.

The new uncoiler features a totally enclosed, oil-tight gear drive and a drag-generator unit which maintains strip tension during slitting and also supplies power for feedup while the strip is being threated through the slitting line. Uncoilers on pull-through lines may employ air or mechanical brakes. However, drive slitting requires

Air Conditioned Crane Cab

..Built..Air Conditioned

and guaranteed by Lintern

Lintern air conditions existing cabs and also builds solid, well insulated replacement cabs to your requirements.

This new Lintern cab complete with air conditioning is shown as it was being installed at National Tube Division of United States Steel, Lorain, Ohio. In the same plant Lintern crane cab heaters as well as air conditioning equipment have been installed on new cranes.

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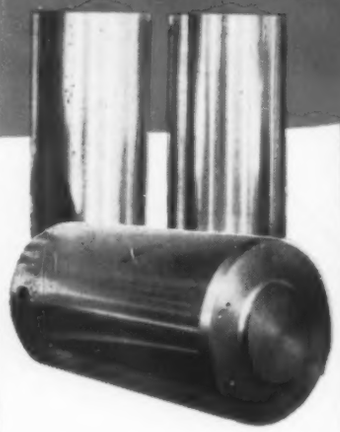

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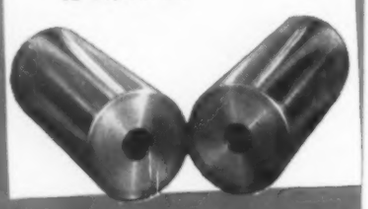

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extremely fine tension adjustment. The new uncoiler-brake design is the perfect solution to light-gage slitting needs.

The welded-steel uncoiler housing is mounted on a sub base, which has a deep V-way. The uncoiler can move forward, accept an incoming coil and reposition for the slitting operation. A hydraulic cylinder positions the uncoiler.

The new uncoiler has a 4-segment expanding mandrel. Among many options available are a 3-segment mandrel, driven hold-down rolls, and automatic edge control.

SCREW CONVEYORS

△ A compact screw conveyor drive especially designed for short conveyor flights and low horsepower requirements is announced by Dodge Manufacturing Corp.

Identified as Series 100, the new product is offered in two speed ratios: 8:1 for up to 6 hp at 225 rpm, and 18:1 for up to 3.8 hp at 100 rpm.

The new unit consists of a double-reduction speed reducer with packing gland and driving shaft which mounts on a trough end. Trough ends are also available.

As in other Dodge speed reducers, maximum efficiency is assured through the use of heat treated helical steel gears and pinions, all rated accordingly to standards of the American Gear Manufacturers Association.

The drives are designed to triple-seal the reducer unit against invasion by the materials being conveyed. The packing gland is adjustable from the outside, takes standard packing, and may be inspected by sight. Slotted holes in the flange of the reducer permit the unit to be rotated for quick and easy adjustment of V-belt drive center distances.

Heavy-duty tapered roller bearings in the reducer take thrust from the screw in either direction. Driving shaft is mounted in a steel sleeve, and built-in puller facilities changing the shaft without opening the reducer. Entire drive is easily mounted or removed from trough end with three bolts in the reducer flange.

Any desired output speed may be obtained by selecting the correct V-belt drive to transmit power from the motor.

RADIATION PYROMETER

△ A radiation pyrometer which measures temperatures up to 4000 F in applications such as industrial heating furnaces, glass tanks, open hearth furnaces, and rotary kilns is now available from Bailey Meter Co. Designated "Pyrotron," the unit measures the intensity of radiation from a hot object and, in conjunction with an electrical receiver, converts the radiation measurements into temperature measurements. Accuracies within plus or minus one per cent of temperature span are achieved.

High signal output of 60 millivolts at 2200 F permits the use of an a-c type receiver-recorder. Output of the pyrometer can be transmitted to a recorder up to 500 ft away. The a-c bridge circuit in the receiver requires no standardized voltage, preamplifier, or d-c to a-c converter. Ambient temperature compensation is eliminated in the pyrometer by including a heating element and thermostat within the case to maintain the internal temperature at 250 F.

A built-in optical sighting system provides a visual check of correct alinement. It also permits a check of the radiation source to assure that it is of adequate size.

Radiation from the object to be measured is focussed by a lens on a lens on a blackened receiving disk in the bolometer. The disk is in good thermal contact with the bolometer filaments. The radiant energy causes the bolometer filaments to change electrical resistance according to the amount of energy detected.

The filament of the bolometer is one arm of an a-c Wheatstone bridge measuring circuit. As the electrical resistance of the filament varies, a null-balance amplifier in the receiver continuously positions a servo motor and measuring slidewire to maintain the circuit at balance.

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see your doctor.
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ask your Heart Association.
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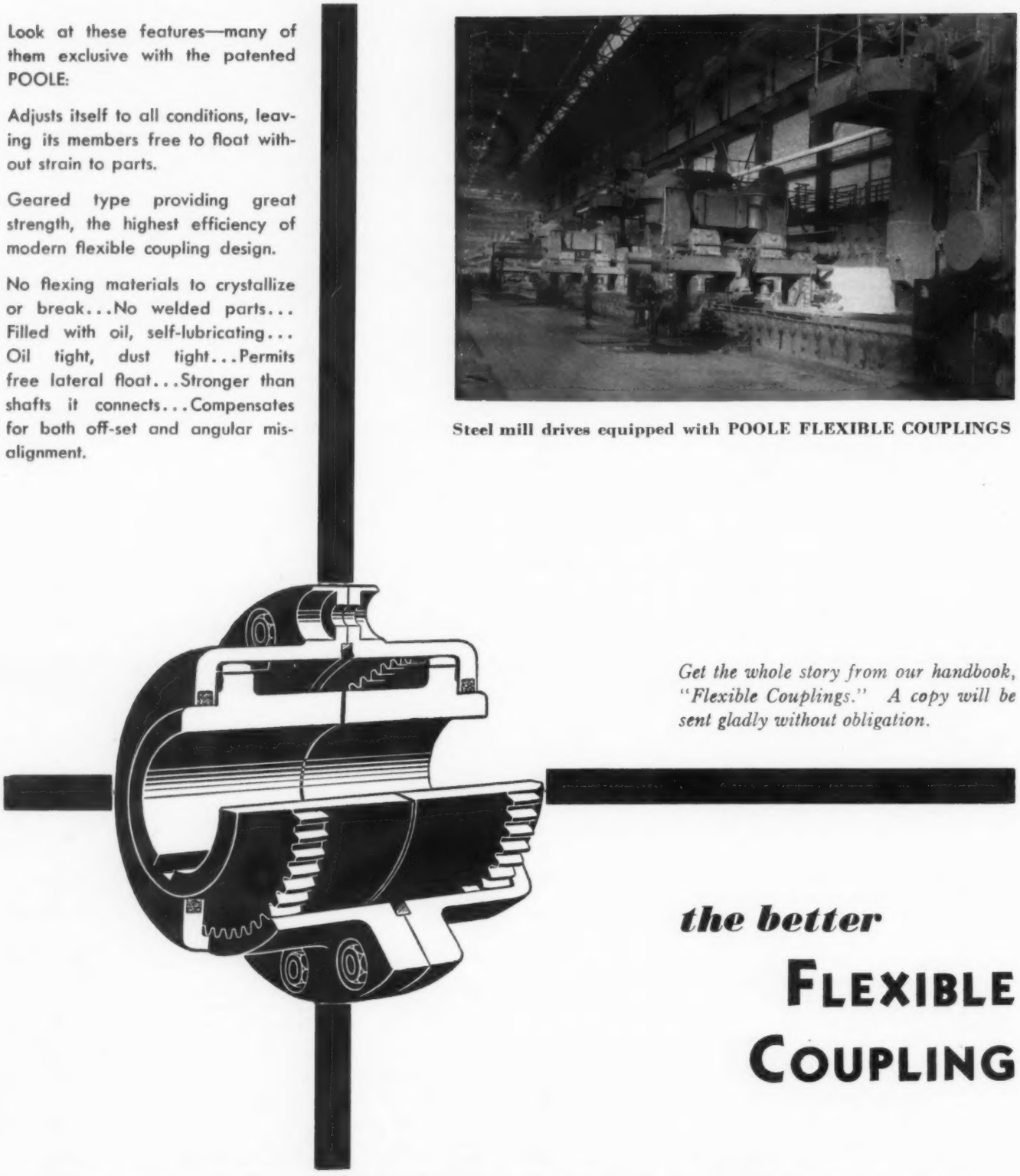

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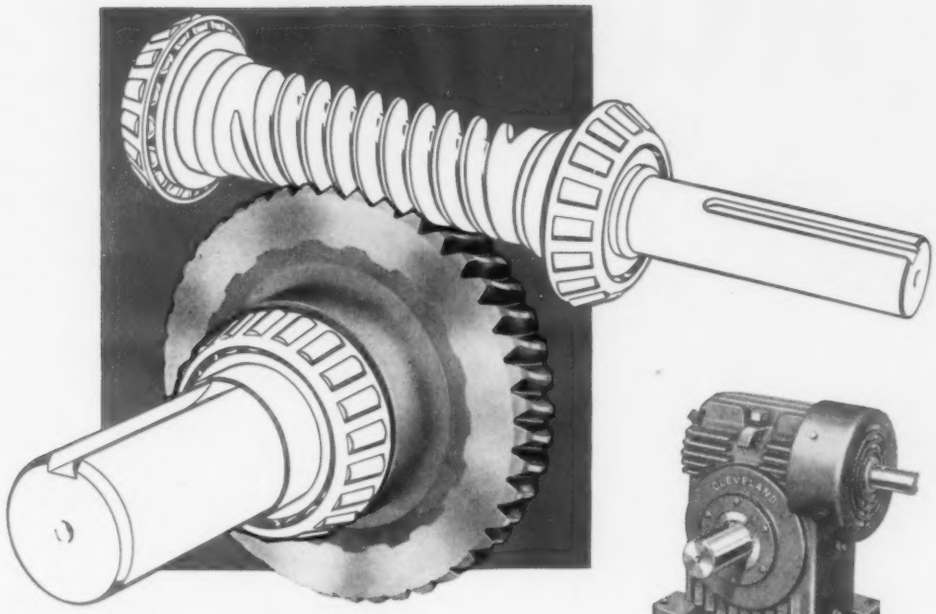

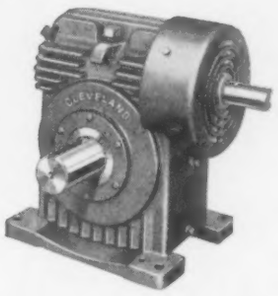

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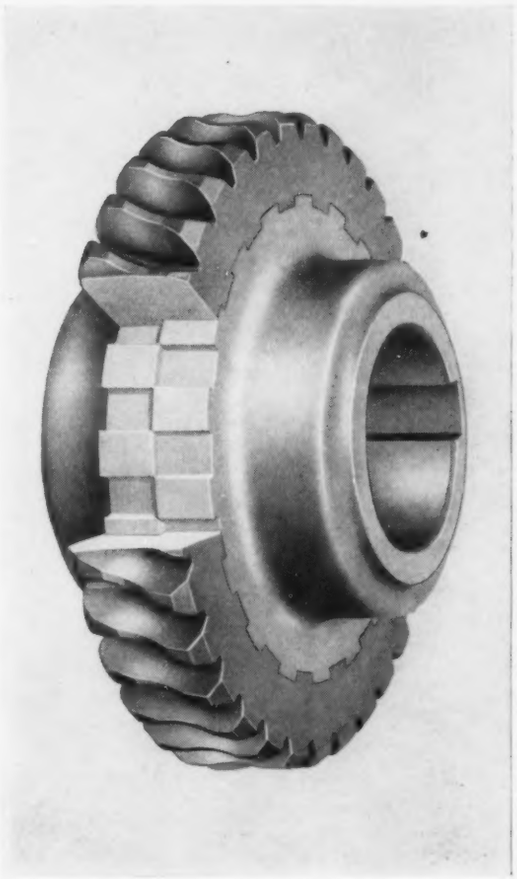

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These rugged bronze rims are cast integrally with their supporting cast iron hubs (see photo at right). Checkered hub circumference holds the rim securely in position, making the two members independent of actual surface bond.

Also, another plus value of the New Cleveland Reducers is their especially large gear shaft diameters—which provide greatly increased overhung load carrying capacity.

For complete facts on this New Cleveland Speed Reducer Line, consult your local Cleveland Representative. Or, write us direct for free Bulletin No. 405—it gives *complete* engineering information for designers and engineers.

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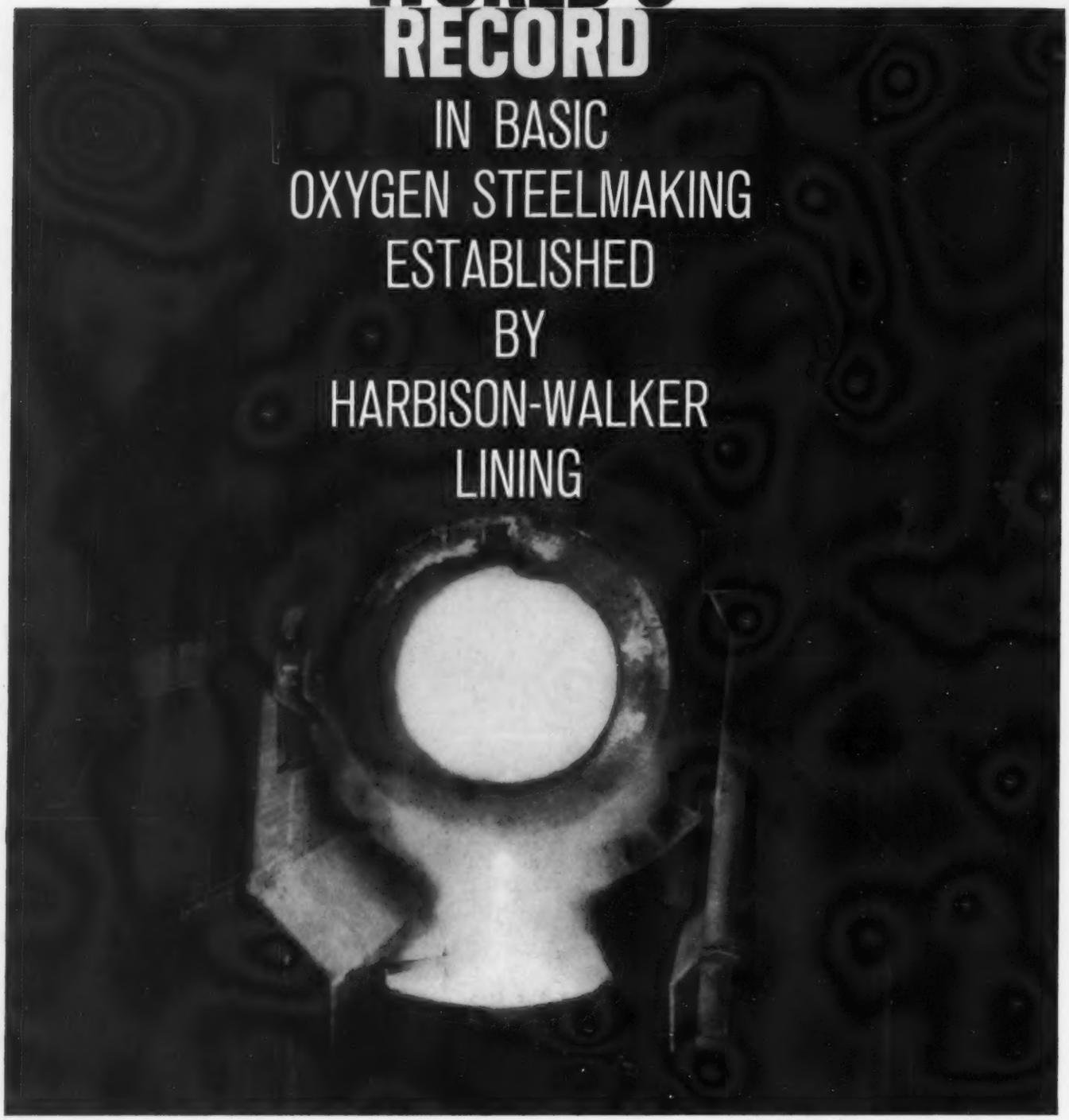

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